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CONTENTS

Revised Phase 3D Design Finalized 1
By Dick Jansson, WD4FAB, Dick Daniels, W4PUJ, Bill Tynan, W3XO

Apogee View 3
By Bill Tynan, W3XO

S Band Reception: Building the DEM Converter and Preamp Kits 4
By Ed Krome, KA9LNV

A 60cm S-Band Dish Antenna 7
By James Miller, G3RUH

The AMSAT Awards Program . 10
By Andy MacAllister, WA5ZIB

RUDAK-II on AMSAT OSCAR-21 Full System Overview, Current Activities and Future Planning 14
By Peter Guelzow, DB2OS

Spotlight On: KITSAT-OSCAR-23 17
By John A. Magliacane, KD2BD

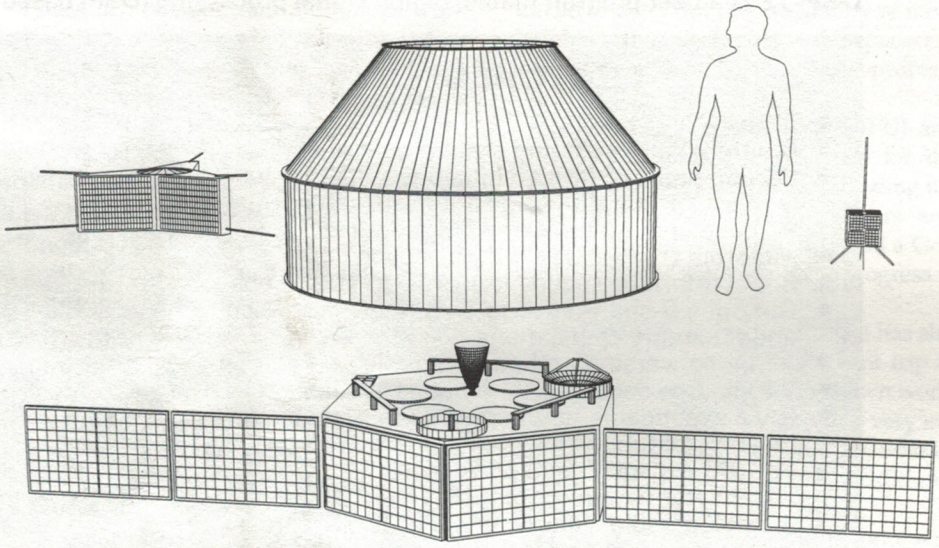
AMSAT Phase 3D Antenna Design Review Phase 3D HF/UHF/Microwave Antennas 18
By Stan Wood, WA4NFY
Dick Jansson, WD4FAB

Tracking the Army/Navy Football Game Via Packet 26
By Bob Brunings, WB4APR

A Tribute to Gus 28
By Clarence L. Humber, VE1HD

Heard on the Downlink 29
By John Hansen, WA0PTV

Revised Phase 3D Design Finalized



By: Dick Jansson, WD4FAB
Dick Daniels, W4PUJ, and
Bill Tynan, W3XO

A meeting of key individuals participating in the Phase 3D design program was held in Orlando, Florida February 25 through 28. This meeting represented an important milestone in the Phase 3D project. At it, the overall design of the satellite was agreed upon. It will be a hexagonal design 1120 mm (44 inches) on each side and 675 mm (26-1/2 inches high). Its mass will be about 400 kg (880 lbs). Solar panels will cover two of the flat side surfaces and two more panels will unfold using a double hinge mechanism. The total span, with these panels deployed will be about 6450 mm (21 feet). Phase 3D will be carried by the Ariane 5 launcher inside a large cylinder and ejected from it.

A major decision reached involved relocating the high gain antennas. In previous designs, these antennas were on the side opposite the nozzle. While this provided more area for them, it also entailed a severe restriction on their height caused by potential mechanical interference with parts of the launching rocket. This height restriction dictated the use of low profile patch arrays for most bands.

(continued on page 13)

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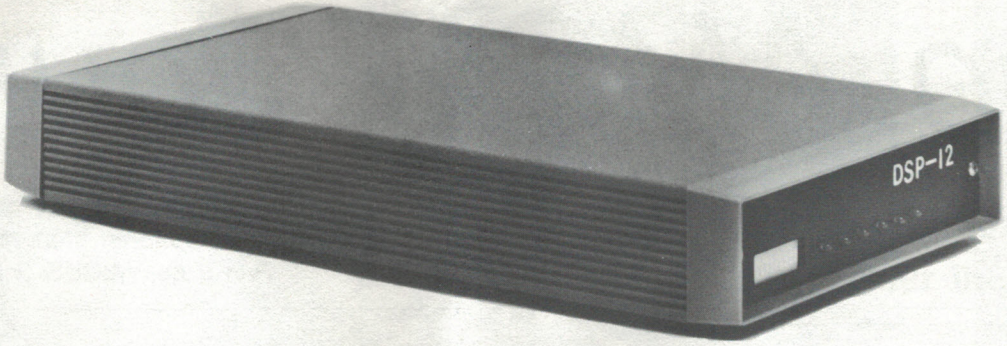

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Phase 3D on Track - but!

By: Bill Tynan, W3XO
President AMSAT-NA

The article by Dick Jansson WD4FAB and Dick Daniels W4PUJ, appearing in this issue of the Journal, shows that progress continues to be made on the design of Phase 3D. A significant amount of work has been accomplished since last November's about- face on the part of the European Space Agency - forcing a major change in the spacecraft's design. Now, thanks to the hard work on the part of WD4FAB in designing a new configuration and the negotiating skill of AMSAT-DL President Karl Meinzer DJ4ZC, we have a design approach which ESA officials say can be accommodated on the Ariane 5 launch vehicle. While we now have a much lighter and, generally better, spacecraft design than before, the need to re-do everything caused a lot of trauma and necessitated the scrapping of some expensive hardware.

At the meeting recently held in Orlando, the overall mechanical design of the Phase 3D satellite was finalized, including a change is the location of the high gain antennas. The meeting also involved a review of the status of the various systems to be incorporated. The spacecraft structure and heat dissipating mechanisms can now be tackled in detail. These tasks are in the capable hands of WD4FAB. From previous experience, I am confident that they will be completed in time to meet the required schedule. Speaking of the schedule, Keith Baker KB1SF attended the meeting and volunteered to handle that important management task. Since Keith has been doing this sort of thing for the U.S. Air Force, and is now retiring, I am sure, that from now on, the Phase 3D design team will have a good grasp on what the project needs and when.

An important part of the Phase 3D project, the antenna designs, came in for considerable review at the meeting. Stan Wood, WA4NFY has been working diligently on the design of radiators for the lower bands, including to the testing of many promising ones on his own backyard antenna range. Antenna work for the higher bands has been undertaken by students at Johns Hopkins University. Bob Stillwell, a perspective recruit to Amateur Radio, reported on this work which has experienced significant progress. However, the change in location will entail a lot of reconsideration of the specific designs produced to date. But the availability of more height on the nozzle side of the spacecraft will make the over-all antenna problem much easier.

As noted in the article by W4PUJ and WD4FAB, the basic architecture for the spacecraft computer system, including the local area network (LAN) appears well defined. Peter Gulzow DB2OS and a German team have made excellent progress in this area.

The JAMSAT camera experiment has also made good progress. On a recent trip to Japan, Tom Clark W3IWI was shown working prototype hardware, and was very impressed. Miky Nakayama JR1SWB, who attended the meeting provided additional details.

Spacecraft power systems are quite well defined, though actual sources of solar cells and batteries have yet to be identified.

The attitude control system came in for quite a bit of discussion. The concept, put forth by W3IWI, to utilize GPS for attitude determination was concluded to have merit; although it was emphasized that the spacecraft will also carry sun and earth sensors. Tom also proposed a central oscillator, the output of which could be controlled to reduce the effect of Doppler. He noted that this might be mandatory at 10 GHz. He was asked to continue working on both of these systems and come up with specific designs and/or individuals or groups to build hardware.

With all of this impressive progress, the amazing thing to this writer was the realization that the systems for which specific designs and responsible agents are the least defined are the RF units - the very things Phase 3D is be developed to support. The Finish group continues to make progress on the 10 GHz transmitter. DJ4ZC assured everyone that the 70 cm transmitter can be built in Germany. The same is true of the IF matrix. The South Africans, although not represented at the meeting, appear to be on-track with the 10 meter bulletin broadcast transmitter.

(continued on page 30)

S Band Reception: Building the DEM Converter and Preamp Kits

By: Ed Krome, KA9LNV
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Over the course of operating S band for several years, being an incurable homebrewer and talking to other ops, I have seen a variety of reoccurring operating and equipment problems. This paper will address a few of these performance pitfalls and what to do about them. I will deal mostly with hints on how to build the Down East Microwave S band converter and preamp kits. I will also detail a method of improving the performance and stability of the most common homebrew S band preamp.

Receiver Performance

The key to good operating on any satellite band is good receive performance. No amount of transmit power will compensate for an inadequate receiver. We have all heard the people who just keep turning the power up when they can't hear their own downlink, and blasting everyone around them. Since most satellite ops use commercial equipment, improving receive performance is usually little more than making sure cables and connectors are correct and equipment is functioning properly. Mode S, however, can be quite a different story.

S Band Operations

S band at 2400 MHz is our highest present satellite band. Three active satellites have S band transmitters. AO13 has a full featured non-inverting transponder with regularly scheduled operation. It works great. PACSAT, whose normal operating scheme is mode J (uplink on 2 meters, downlink in 70 cm) also has an alternate downlink on 2401 MHz. While this is not a regularly scheduled mode, it is typically turned on on experimenter's days when sun angles are correct. DOVE has a 2401 MHz downlink telemetry beacon. With DOVE's operating problems, its normal mode of operation is in S band. Unfortunately, a phase modulator failure has left the telemetry undecodeable. However, if DOVE did not have this beacon, it would have been completely lost long ago.

Reception on S band is not difficult. PACSAT can be heard with a 2 foot long helix antenna. AO13 requires an 8 foot long loop yagi or small dish. Since signals are weak, noise is the biggest problem. To keep from introducing undesirable system noise (remember that coaxial cable is extremely lossy at 2400 MHz, and cable loss is indistinguishable from noise), most operators install low noise preamps as close as possible to the antenna. Then a run of standard coaxial cable is connected between the preamp and the receive converter.

Converters

One of the neatest things about S band is how easy it is to become active on our highest (and highest tech) band. Your can buy ready-made converters and preamps from either SSB Electronic or Down East Microwave. Or, if you are feeling adventurous, but kits from Down East Microwave and "roll your own".

The DEM kits are interesting. While they are not Heathkit (rest its soul), they do get the job done. The DEM kits are kind of like a short magazine article, a circuit board and a bag of parts, some almost microscopic in size. Photos are included; these make parts placement and building a breeze. And the no-tune design almost insures that they will work. But standard HF (and even VHF) construction techniques won't work on 13cm.

The Local Oscillator

Building the Local Oscillator is straight forward. Just make sure you get the transistors and MMIC's in correctly. Remember that the really small MMIC cases (.085 inch diameter, called either MAR-x (if manufactured by MiniCircuits) or xx85 if by Avantek) have the input lead at the color dot, while the larger case style (.140 inch diameter, called MAV-x or xx04) has the output lead at the dot. Be sure to supply the +13 VDC to the board through a feedthrough capacitor. The LO can be mounted upside down underneath the converter board (groundplane to groundplane) and tack soldered to it.

Mounting MMIC's

The downconverter itself is a little harrier, but takes less time to build than the LO. The method of grounding the MMIC ground leads is probably the trickiest part. The instructions say to bend the 2 ground leads through the previously drilled holes and solder to the ground plane. That means just what it says, bend the ground leads (carefully; they can only be bend once and they will break) down flush with the sides of the MMIC case and thread them through the holes until the input and output leads are flush with the top of the circuit board and resting squarely on their respective traces. I have found it best not to tin either the MMIC leads or the board traces before inserting the MMIC's so the devices don't sit up on top of a lump of solder. They must be flush with the board. If the input or output leads are too long, cut them, they don't mind. After inserting the MMIC, solder the input and output leads in place (use a grounded, low wattage iron). Then bend the ground leads outward from the device on the bottom side of the board against the groundplane and solder carefully. Inspect with a magnifying glass to insure no shorts exist. As a matter of fact, inspect for shorts BEFORE you solder also; these things are VERY difficult to repair.

Soldering Chip Caps

To solder a chip cap in place, use the following technique. First, lightly tin one mounting pad (only) and one end of the chip cap only. Then, position the cap on the board with a tweezers, tinned end over tinned pad. Hold the cap in place with a toothpick. Then touch the tinned pad/tinned end with your small soldering iron. When the solder melts, the chip will settle into place. By only tinning one end, the chip will settle down flush with the board on both ends. After the chip is in place, solder the other side in place. Easy. Go down to Sears and buy a set of headband binocular magnifiers so you can see what you're doing. Don't guess.

Input Circuitry

Getting the signal into the board with a minimum of disruption or impedance discontinuities is of major importance, and is not addressed well in the instructions. You simply cannot build up the boards, stick them in a metal box and run a piece of hookup wire from the input connector to the board. Probably the easiest method of mounting the board in a diecast box and connecting it to the input connector is to use subminiature Teflon coax to connect the two. Use VERY short ends on the coax. Ground the shield at the board end directly to the groundplane under the RX IN trace. Even an extra 1/16 inch is critical. To attach to the input connector (usually a type N), mount a flange N in the box. Then take the mini coax and strip it with

the minimum possible amount of insulator showing between the inner and outer conductors (the idea here is to preserve the 50 ohm impedance). Then wrap a solder lug or piece of thin brass shim stock around the outer conductor and solder it in place. Position the lug so it can be bolted to the cast box under one of the connector bolts in such a manner as to hold the coax inner conductor as close as possible to the connector center lug. Wrap the center conductor around the center lug, as close as possible to the insulator, then solder it in place. Cut off the extension of the connector center lug. This technique may not be the absolute best for this band (still rather lossy), but it works. One S band converter I repaired seemed to work OK electrically as I received it, but was incredibility insensitive. Simply changing the input connection from the original hookup wire arrangement to the coax method detailed above improved the converter's sensitivity by over 20 db! Proper grounding of the MMIC ground leads added another 5 db. Tender stuff.

Probably the best method of building the converter is to do the most basic thing. Solder a 3/4 inch wide strip of hobby brass strip (.015 thick is fine) all the way around the board, with a 1/8 inch flange below the board to solder to the groundplane. On the front (input end), before you solder it in place, drill a hole in the brass strip that will allow the direct mount of a flange-type SMA connector. Solder the flange to the brass strip and the center conductor to the RX IN trace. Then (after adding the other required holes) solder the rest of the strip to the ground plane. Be sure to include another small hole over the LO IN trace and connect the board to the LO with submini coax. Also, mount feedthrough capacitors through the strip over the DC input pads. The biggest problem with this technique is that it makes it difficult to mount the board in a die cast box. Too many connectors hanging out of one end. This can be overcome with a piece of mini Teflon coax and connectors from the board SMA connector to a feedthrough connector (N or SMA) mounted in the end of the box. Connect the 2 meter output to any output connector with another piece of submini coax. Ground the shield at both ends. Route it around the outside of the board away from the RF traces.

Preamp

DEM's 13 cm preamp, designed by Al Ward WB5LUA with help from WA5VJB, is a marvel. Only one device, no tuning and 10 db of gain with a noise figure under 1 db. Easy to build, too. But, as with the converter, you have to be careful of impedance bumps and lead lengths.

The preamp board must be surrounded by a 1/2 inch strip of hobby brass. If you don't mount the preamp in another enclosure, close the top of the box by tack soldering a thin brass cover to the brass strips. After you get it all working, of course!

I have found the best sequence to building the preamp is to first make the through-board grounding connections required for the source bypass capacitors (next paragraph). Then solder the brass strip all the way around the board. At the same time, mount the input and output connectors. Finally, mount the other components. This order of assembly prevents thermal and physical stress on sensitive components.

Mounting the source bypass caps to the board can be challenging. Insuring that they are adequately grounded should be the first operation. Using a sharp Exacto knife, slice through the board on the inner edges of the 2 pads on either side of the GaAsFET mounting area. Then thread a strip (cut to the same width as the pads) of the supplied thin copper stock through the slits in the board. Bend the copper over the small pads on the top and onto the ground plane on the bottom. Smooth and flatten it on both sides. The back end of the Exacto knife (metal) handle works well. Do not completely cover the top pads so the foil can be soldered to those pads. Insure that there are no shorts to ground before soldering the foil in place. Then tin the bypass caps (trapezoids cut in half or leadless discs), position them as instructed (.07 either side of the device body). Hold them in place with a toothpick, then heat the solder from the bottom of the board with a 30-40 watt iron. The heat will transfer through the copper tape and melt the solder on the pad and under the bypass cap. You will feel the cap settle into place.

The preamp is really sensitive to input and output impedance matching. While it seems to be quite stable, mismatches really ruin the gain and noise figure. Once again, I have had the best results with soldering flange-type SMA connectors directly to the brass strip around the board. A hole is drilled in the brass strip the same diameter as the Teflon insulator of the connector, then the connector is soldered to the strip. Position the strip and connector on the end of the board so the center conductor rests directly on the board trace. Solder everything in place. I have used several other methods, including the submini Teflon coax method described earlier (keep the ends extremely short!), and the use of extended inner conductor type N connectors (see photo). A note on the method shown in the photo: be sure to ground both ends of the tube extension. It serves as the outer conductor of a piece of hardline between the connector and the board. For sure perform-

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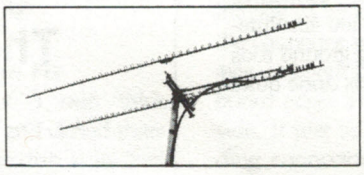

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ance, use the SMA connectors soldered directly to the brass strip method. You may also be able to find type N connectors with mounting flanges and flat backs. These can be soldered directly to the brass strips and the board trace in the same manner as detailed for SMA's.

Preamp Mounting

The preamp must be mounted as close as possible to the antenna feedpoint. How close is close? How about taped directly to the underside of the antenna (a loop yagi in this case) boom? A few inches from the driven element seems to work pretty well. Will a small dish, mount it right at the feedpoint directly to the driven element.

The fact that satellite mode S is a receive only mode has another advantage. You don't need any method of switching from receive to transmit. For a real pocketbook thrill, try pricing a good SMA transmit/receive relay sometime. Since I use an all-metal loop yagi (and it is grounded), I leave my preamp connected to the antenna all the time. The all metal construction insures that any atmospheric static electricity picked up will simply be routed to ground, not through the gate of the GaAsFET in my preamp. In several years of thunder and lightning shows (and dry snow, which generates an amazing amount of static electricity), I have never lost a preamp. Of course, this would not survive a direct strike, but if that happens your 13cm preamp is the least of your problems! Remember, lots of ground rods are absolutely essential. A network of 15 long ground rods and 3/8 copper pipe for cable has done quite well here.

Preamp Mods

If you have a long run of cable from your antenna/preamp into the shack, a second preamp, also tower mounted, is useful. There is a fairly simple method of converting the DEM preamp to a 2-stage design and improving its performance.

Rather than adding a second GaAsFET to the DEM preamp, it is easy to add an MMIC second stage, right on the existing board. This mod will add almost 10 db of gain to the preamp without seriously effecting the noise figure. Since the MMIC is unconditionally stable, it will also insure that the preamp is stable under any output load.

Add an 0685 (or MAR-6) MMIC to the output trace between chip cap C2 and the output connector. First, figure out how much output trace space you need to properly mount the chip cap C2. Then drill a .09 hole through the circuit board, directly in the center of the output trace, leaving 1/16 clearance between the edge of the hole and the end of C2. Be sure to remove all traces of copper from the sides of the hole to prevent shorts. Then place another 10 pF chip cap (like C2) on the trace, with its edge about 1/16 inch beyond the edge f the hole you just drilled. Mark its position on the board, then remove the chip and cut a .03-.04 inch section out of the trace under where the new chip will be mounted. Solder the new chip in place on the end opposite the hole in the board. Bend the ground leads of the 0685 MMIC straight down and insert them through the hole. Cut the input and output leads very short so they will lie flat on the circuit board top traces between C2 and the new chip cap. Bend the leads out to the ground plane of the bottom and solder all leads carefully in place. Then (see photo) position one 560 ohm resistor lead over the output of the MMIC. Solder several chip caps (.100 size; use a 100 pF, a .001 mF and a .1 mF) to the ground plane or brass wall strip. Keep all leads as short as possible. Route the resistor lead so it can be soldered to the tops (ungrounded ends) of the chip caps (used here as bypass caps) and the other lead to the output lead of the MMIC. Before you solder anything, route the resistor lead down the back wall of the box away from any RF traces and around to the DC pads. It is to be connected directly to the +12 VDC line into the preamp, before R4. Carefully position all leads so they fit with no mechanical stress, then solder all in place. Be careful you don't break the chip caps. If you do, start over. That's all there is to it.

Finally

Mode S is the state of things to come and is not difficult or expensive to implement. I hope these suggestions will encourage people to build these kits and become active on this excellent band.■

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A 60cm S-Band Dish Antenna

By: James Miller, G3RUH

[This article first appeared in Amsat-UK's Oscar News, Number 100, April 1993]

My recent article [1] proposing the abandonment of the 145 MHz band for weak signal amateur satellite downlinks has sparked much interest. I explained why S-band (2.4 GHz) is unrivaled on every count as its replacement, and described in outline a tiny 60 cm diameter dish that is entirely adequate for Oscar-13. Naturally I have had many requests for more details.

Let me stress once again, you need absolutely no knowledge about S-band to get going, anymore than you need knowledge about 2 meters to get onto mode-B. Just accept my word that S-band is easier by far. I started this project with absolutely no understanding of S-band, designed and built it all in an afternoon's pleasant metal bashing.

Take a look at your 2 meter antenna. Surely it's just a load of mechanical bits and pieces juxtaposed to behave electrically in a special way. So too is an S-band dish antenna.

Don't Panic!

There are three parts to this dish. The parabolic reflector, the boom and the feed. This article is about each of these, and how to fix the reflector and feed to the boom in the right places.

There are as many ways to do this as there are constructors. I'll tell you my way. You don't have slavishly to replicate every nuance of the design. No dimension is critical except for a small bit of the feed system. No exotic tools or test equipment are needed. You have all you need already; hands, hacksaw, file, ruler. Throw it together, and it will work. I know; I did it. At the end of your toils you will have a 60 cm diameter S-band dish antenna with a gain of about 20 dBi RHCP, a 3dB beamwidth of 18 degrees and, with the suggested converter, more than adequate performance to experiment on AO-13 mode-S.

The Parabolic Reflector

I went into a shop to look for some furniture; the lobby looked perfectly normal. The stairs were closed so I took the elevator. I emerged into a disaster area. Evidently the shop was in the throes of closing down for good. In the rubbish I spotted a couple of once trendy, spun aluminum parabolic lampshades in a vile buff color, and bought them for as little as I could get away with. "Might come in handy one day".

The dish measured 585 mm diameter, and 110 mm deep, which translates into an f/d ratio of 585/110/16 = 0.33, and thus a focal length of 0.33 x 585 = 194 mm. An f/d of 0.33 is rather too concave for a simple feed to illuminate ideally, but at $4/dish who cares? It works, and the final antenna is much more compact than the usual shallow dish of f/d=0.6

The dish has a 40 mm hole in the middle with three 4 mm convenient holes around it on a 1 inch radius circle, presumably a standard for lighting attachments. So absolutely no modifications were needed to the parabolic reflector.

The Boom

This is made from a length of 12.5 mm square aluminum tube obtainable from any non-ferrous metal supplier or engineering shop. It has to be long enough to stick out the rear of the dish to provide an extension to clamp to the rotator boom (150 mm), long enough to put the feed at the focus (+194mm), and long enough to fix the feed and converter assembly (+186 mm). So it is about 530 mm long overall. The clamp is a cheap UHF TV antenna type.

Parabola to Boom Fix

I hacked out a disc of 3 mm thick aluminum, 65 mm diameter and drilled three 4.3 mm fixing holes using the dish as its own template. Then I filed a 13 mm sq square hole in the middle for the boom to pass through. The disc is attached to the boom by four little 15 x 15 x 10 mm wide pre-drilled angle brackets. These items are usually used to mount small boxes to panels etc. You can bend and drill your own, but I used a standard item costing a few cents.

Thus there are four more 3.3 mm holes around the center of the support disc, and two 3.3 mm holes in the boom. Obviously two angle brackets face forwards, and two face rearwards, otherwise the through-boom screws will foul each other.

The Feed Assembly

This comprises several components: the helix feed, match and N-type panel connector, feed reflector, and S-band converter.

Converter

As Ed Krome points out in his excellent survey of S-band [2], there is no such thing as an ICOM/KENWOOD/YAESU FT24000 transceiver. He might have added, nor is there ever likely to be. This is not a marketing problem, it's an electrical one. Any antenna necessarily has to be some distance away from the radio. But coax less than 1" hardline attenuates 2.4 GHz signals like crazy. This wipes out the advantage of S-band, which is the almost total absence of ambient noise.

So there has to be some receive electronics at the feed, such as a receive pre-amplifier or a converter, 2.4 GHz to 144 MHz for example. This puts the low noise receiver and its gain right at the masthead, and the downlead can be inexpensive lightweight RG58/U coax.

I used a model UEK-13-P3C from SSB Electronic. Note the suffix -P3C. This denotes 2400-2402 MHz, as distinct from the 2304 MHz version.

There are also converters available from Down East Microwave, and a number of specialist designers "advertise" regularly in magazines like VHF Communications and Dubus. See also VHF/UHF/Microwave handbooks (ARRL and RSGB) and the UHF Compendium from Germany.

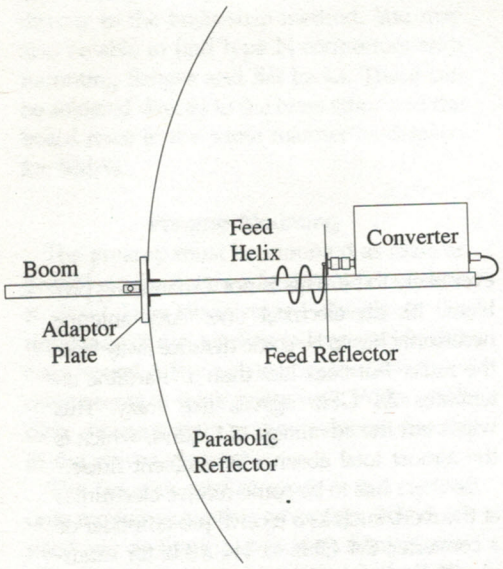
An S-band helix has a radius of approximately 21.25 mm so, if fed at its periphery, the connector would be 21.25 mm from boom axis, or about (21.25-6.25) = 15 mm from the boom edge. This time Murphy was on my side. It just so happens that the corresponding connector on the converter is 15 mm from its edge too. So if the converter is clamped directly to the boom, the two connectors line up perfectly. Since an N-type connector has the mating strength of two elephants, it can also support the entire feed assembly! Thus the helix, connector and converter form one sub-assembly which is then clamped to the boom with two large cable wraps. This arrangement also allows it to be slid up and down to peak up the receive signal.

Of course if you use some other converter, the reflector assembly can simply be fixed with two angle brackets in a similar way to the dish attachment.

Reflector

I made this from a 125 mm square of 1.6 mm thick aluminum. It looks prettier if the corners are cropped off 10 mm but this is not essential. The reflector could also be 125 mm circular. It's just easier to cut straight lines than round ones.

There is a 13 mm square hole in the middle once more, and the N-type panel connec-



"60 cm Dish Antenna for S-Band"

tor is affixed approximately 21.25 mm from the middle as described above. Get the exact dimension needed by carefully measuring the converter. The N-type panel connector is actually mounted on a 1.6 mm thick spacer so that the back of the connector is flush on the helix side. Drill and fix with three screws only, as the fourth will foul the start of the helix.

Helix

This is 3.3 mm diameter copper wire. In fact it's the solid inner stripped out of a length of H100 coax (similar to Belden 9913). You need about 1/2 meter. Wind it all, about four turns, around a 40mm diameter form. I found a socket in my car tool kit that was perfect. It will spring out slightly after winding. Wind it left handed, that is to say in the opposite sense to a conventional screw thread. As you look at it from one end, it will recede anti-clockwise.

Now carefully stretch the helix to a turn spacing of 28 mm (+/– 1 mm). Make sure it is nice and even.

Cut off and discard the first 1/2 turn. Now, with careful use of pliers bend the first 1/4 turn about 10 degrees so that it is almost parallel to the reflector again. This will form part of the matching section.

Next you need a very thin brass strip, about 0.2 mm thick, 6 mm wide, shaped to follow the curve of the 1/4 turn you just bent. It will go flat between that turn and the reflector. Use the 1/4 turn as a template onto a piece of paper.

Since the copper is 3.3 mm wide, and the strip needs to be 6 mm wide, a line 1.4 mm away can be drawn both sides of the copper with a fat pencil. Judicious use of clamps, weights, blu-tack and adhesive tape will provide the six hands needed to do this! Spend plenty of time to get this drawing just right. Then tape the paper to the brass, and with great care use a pair of very sharp scissors to cut out the shim you have sketched.

With more fiddling as above, trap the shim between copper and a flat heat-proof surface, and with a 60 watt iron and large tip, solder the shim to the copper all the way along its length. If you make a mess, dismantle, wipe clean and start again.

You should now have a helix which has a brass shim soldered to its first 1/4 turn essentially flat to the reflector. Cut off the surplus turn(s) from the helix so that you have a total of 2 1/4 turns including the matching section.

Finally solder the helix to the pip of the N-type. The spacing of the matching section should be 1.2 mm at the start by the N-type and 3.0 mm at the end. Use scrap bits of metal sheet to jig this up, carefully bending here and there to get the whole edifice just so, match spaced properly, helix axis perpendicular to the reflector. This also needs six hands. Finally apply a very generous blob of solder to the end of the helix and N-type. This will be the only fastening for the helix. It may have a propensity to twist. Sealant will cure this later.

Final Assembly

You can now couple the converter to the connector. As I used a male panel connector, it coupled directly to the female on the converter. However male panel connectors are often difficult to find, so you will probably have to use a female panel connector, plus a male-male coupler.

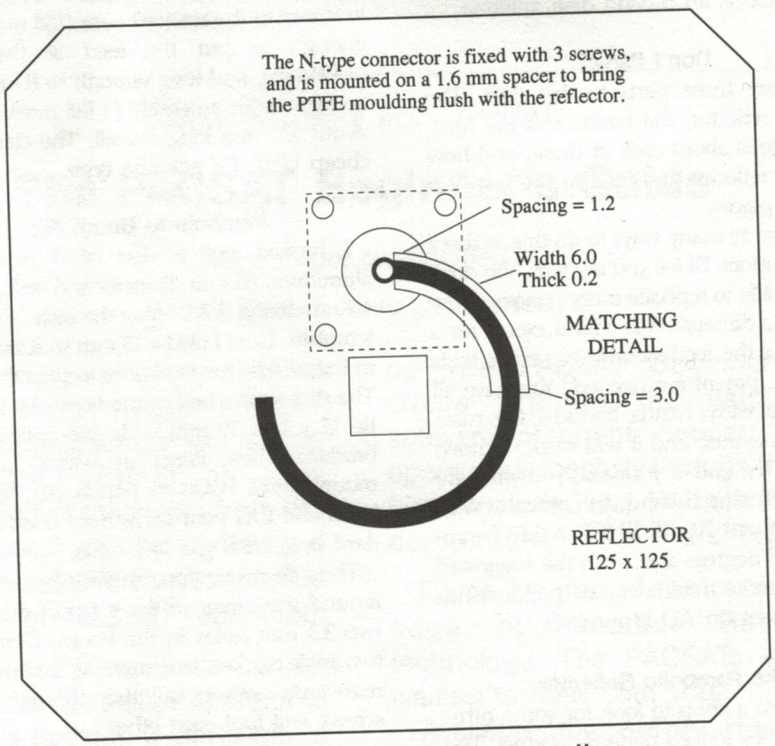
Slip the assembly over the boom, and slide it to the correct position. The middle of the helix should be at the dish geometric focus, 194 mm from the parabola on my own model.

Attach a BNC connector to a suitable length of RG174/U coax, and pass it down through the boom, together with the +12 V wire, to emerge at the rear and link up with your system. The coax outer provides a return, so only one power wire is needed.

Testing

You need a 2.4 GHz signal generator, an RF detector and a power meter.

What? You don't have any of these? Wrong! The Sun is your signal generator, the 144 MHz SSB radio is your detector, and an ordinary moving-coil AC meter is the power meter.



"Helix feed matching system"

Don't get too paranoid about precision. I guessed the prototype's matching, and it worked great. Then I took it to a friend's 3 GHz network analyzer. It showed a lousy match. So I designed the new perfect one as above. On-air performance was unchanged!

Indoors, connect everything together and switch on. If you now switch off and on power to the converter, you should hear a substantial change in noise output from the radio in SSB mode. The converter is "converting" something at least, so the wiring is probably sound.

Now set up shop outdoors. Choose a location clear of obstructions. Bear in mind the potential danger of using mains-powered equipment in damp conditions.

Power up the system once more. Holding the boom by the rear and above your head, point the antenna towards the zenith, that is straight up. This will be the quiet sky. Listen to the noise level and make a mental note of the volume. Headphones are useful here. Now point the antenna at the ground. The noise should increase substantially, approximately doubling in loudness (+3 dB).

Now point the dish at the Sun. If it is shining, this is easy. If it is obscured by clouds, you will have to use your skill and judgment. Either way, the noise level should rise by about 1 dB. This is only very slight, and is why a meter is helpful. Trees are a 100% attenuator.

Connect the AC voltmeter to the loudspeaker terminals. Set the voltmeter to its most sensitive range, probably 3 volts full scale, and adjust the volume control to about half travel. Note the reading on the meter. Now aim at the Sun, and the voltage reading should increase by about 10%.

This method of measuring noise power is quite accurate provided two conditions are met. First, the audio amplifier must not be limiting through overdriving. You can hear this as a bad crackling noise, or look on a scope. Secondly, the receiver AGC must not be operating. If the S-meter is showing a deflection, the AGC almost certainly is in action, and the AC output voltage will not be proportional to signal strength. You will need an attenuator to reduce the 144 MHz signal. A couple of junk box resistors will do. 1/4 of the signal voltage (-12 dB) is sure to suffice.

Finally wait for an Oscar-13 mode-S session. Just listen around 2400.720 MHz. That will be 144.720 MHz on your 2 meter SSB radio. (Note 144, not 145 MHz). The conversion accuracy won't be very precise, and even with Doppler compensation may well be 50 kHz off nominal. If the mode-B transponder is ON too, you will hear many interfering LSB signals corresponding to mode-B's 145.880 - 145.920 MHz portion.

If the B transponder is OFF, you will hear genuine mode-S stations on USB loud and clear.

There is no such thing as a poor mode-S signal. Anyone who can get a decent mode-B uplink can overload mode-S with ease! The beacon, 70 kHz lower in frequency, is not on at the same time as the transponder. It will be very strong, and decode perfectly at all times.

Figure of Merit

The overall performance of any receive system is a function of only two things. The antenna gain (more = better), and the noise level (less = better). Thus the ratio of gain to noise is a concise indication of the system sensitivity. This is known as the G/T ratio.

The system you have built has a Gain of about $x100$ (20 dB), and a receive noise Temperature of about 200 K. Thus the G/T ratio of your dish is roughly 100/200 = 0.5 (-3 dB). And this is the minimum requirement for AO-13 mode-S.

So if someone else is boasting say a 7 meter diameter dish (Gain $x13600$) and an ultra-low noise preamplifier with an overall receive noise temperature of 100K, then their G/T ratio is 13600/100 = 136. This is 24 dB better than our little dish, so AO-13 signals will be louder. But they won't be any better, because the transponder noise floor will be louder too. And their antenna beamwidth will be only 1.5 degrees, which is irritatingly small for satellite operation. Most az/el rotators rattle more than that!

So how do you measure G/T? Carefully masure the Sun noise increase as described above. Call the noise power ratio Y = (Vsun/Vzenith)2. Then G/T = (Y-1)/0.45 at 2.4 GHz!

Now the "0.45" factor includes a measure of the noisiness of the Sun, and this fluctuates from time to time by a dB or so [3]. However, I find the test is mostly repeatable, and is a reliable indicator of performance for better or worse if you have tweaked something. So make it a regular part of the station checkout routine.

Weatherproofing

When you are happy about the system performance, obtain some Dow Corning clear sealant, and seal the pip of the N-type connector. When set, this will prevent any rotation of the helix. Also lightly seal the lip, spacer amd screw heads on the other side of the reflector. This will keep moisture out of the connector.

The UEK-13-P3C is built into a tinplate box with press-fit lids. It is absolutely not weatherproof or rustproof. The easiest way to keep the rain out is to use a polyethylene bag. Obtain a clear, tough freezer food bag, and pull it over the converter assembly, stretching it around the reflector periphery to make a tight fit. This works well, but is not too robust. There are variations on this theme which will suggest themselves as you contemplate the problem. A second solution is to mummify the converter in self amalgamating tape normally used for connectors.

A more subtle idea is to keep the antenna indoors. It works through a window, open or closed, though the noise level is higher due to the proximity of the warm house. Or it can be put outside on a tripod when needed. It is so small that it is highly portable, passing through doorways with ease. With its 3 dB beamwidth of 18 degrees, it can be aimed once only for a mode-S session on AO-13.

Conclusion

This is a very easy project. In fact I found it the easiest thing I have ever done in ham radio, especially since I knew nothing about dishes and S-band other than the tidbits one can read in articles. You can have practical fun with AO-13, as well as be ready for P3D from day one. When you have succeeded, your appetite will be whetted to absorb even more knowledge about 2.4 GHz.

S-band will no longer be a mystery, apparently accessible only to a favored few. You will acquire a painless introduction to microwave operation - without even realizing it's microwaves.■

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2.4 GHz Equipment Suppliers

SSB Electronic, Panzermacherstrasse 5, W-5860 Iserlohn, Germany, Tel: +49 2371 6454, Fax +44 2371 67593.

SSB Electronic UK Agent: Piper Communications, 4 Severn Road, Chilton, Didcot, OX11 0PW, Tel: +44 235 834328. MC/Access/Visa taken.

US Agent: SSB Electronic, 124 Cherrywood Drive, Mountaintop, PA 18707. (Jerry Rodski, K3MKZ) Tel: +1 (717) 868-5643. MC/Visa taken.

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The AMSAT Awards Program

By: Andy MacAllister, WA5ZIB
AMSAT Vice President User Services

[This article first appeared in the Proceedings of the Tenth Amsat-NA Space Symposium, October 9-11, 1992, Washington, DC]

In addition to awards for single event activities, AMSAT maintains a program promoting several ongoing awards ranging from the introductory Satellite Communicators' Club (SCC) certificate to the advanced OSCAR Century Award (OCA). Requirements for theses achievements go from proof of a single contact for the SCC to 100 qualified contacts for the OCA. Awards at intermediate levels are also included along with one from South Africa AMSAT. Another award based on scheduled transmission and reception tests is the K2ZRO Memorial Station Engineering Award. It has become the most popular of AMSAT's on-the-air satellite competitions.

Introduction

As thousands of amateurs have discovered, chasing satellites can be addicting. There is something very alluring about sending signals through space and making contact with others via amateur- radio satellites or "ham-sats". Many a jaded ham, with walls full of rare QSL's and the familiar DXCC, WAS, WAC awards, has renewed his enthusiasm for amateur radio by earning those awards all over again—along with new ones—through the satellites.

Over the years AMSAT has promoted certificates to commemorate special events like the launch of AMSAT-OSCAR-10, the commencement of AMSAT-OSCAR-13 operations, donations for satellite solar cells, the twentieth anniversary of the launch of OSCAR-1, the Stoner Challenge Cup Competition and additional events. Further programs recognizing long-term activities were begun two decades ago and continue today.

The AMSAT Awards Program provides several awards designed specifically for the satellite enthusiast. The first was the Satellite Communicators' Club (SCC) certificate, started in 1973 after AMSAT-OSCAR-6 was safely in orbit. The intention of this program was to document the use of A-O-6 and to promote activity. Two years later, AMSAT announced a new award, the OSCAR Satellite Communications Achievement Recognition (AOA) certificate, in the June 1975 AMSAT Newsletter. Earl Skelton WA3THD coordinated the program for four years. During that time two other awards were added, the OSCAR Sexagesimal Award and the OSCAR Century Award. Jim Devilbiss WA3FUJ accepted the responsibilities of the Award Manager position from July 1979 until late 1986 when Andy MacAllister WA5ZIB took over the post.

Satellite Communicators' Club

Just as with the low-band awards, some of the satellite certificates are more difficult to earn than others. Only a single satellite contact is sufficient to qualify for the Satellite Communicators' Club certificate. The original certificate had a drawing of A-O-6 in the lower left. It was announced in "Satellite Operating Awards" by Ray Soifer W2RS in the June 1973 AMSAT Newsletter. Today's version shows a Phase-3 style satellite in the lower right corner (Fig. 1). Printing is with dark blue on light-gray textured paper. To receive the award, a report of a two-way contact through any amateur satellite is sent to the AMSAT S. C. C. Manager, P.O. Box 27, Washington, DC 20044. No form is necessary and submission of a QSL is not required. Pertinent information about the QSO along with a SASE and $1 ($2 for non-members) should be submitted. Walt Rader WA3DMF handles this program.

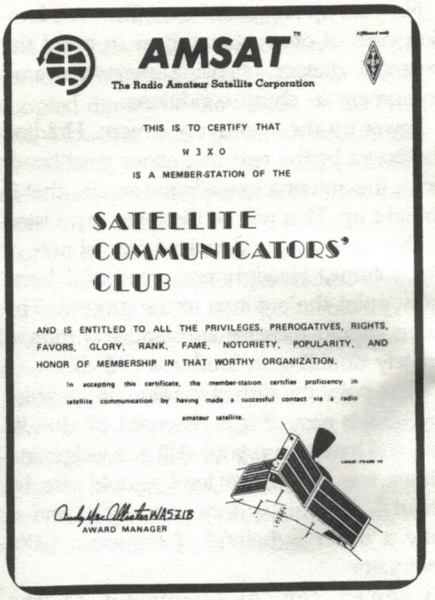


Figure 1

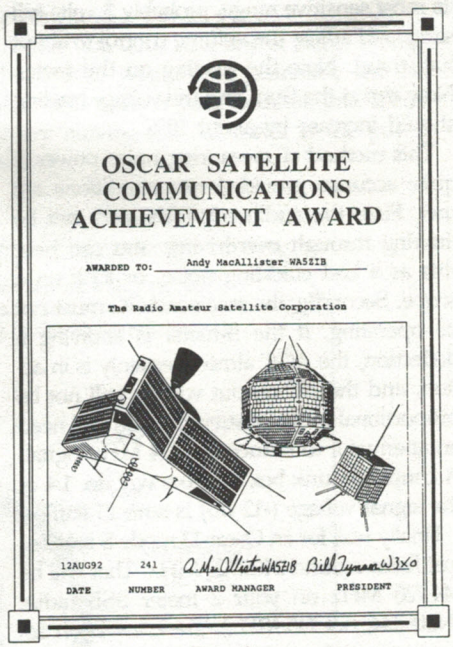


Figure 2

Oscar Satellite Communications Achievement Award

Originally known as the OSCAR Satellite Communications Achievement Recognition, the OSCAR Satellite Communications Achievement Award (renamed in 1992) is also known as the AMSAT OSCAR Award or AOA. This accomplishment requires proof of 20 qualified satellite contacts. A qualified QSO is one with a different state, Canadian call area or DXCC country, in any combination. Endorsements for each 10 QSO's above 20 are available only for those with certificates dated prior to 1992 when the certificate was updated (Fig.2). Printing is black on beige textured paper. The cost of the award is $3.50 for AMSAT members and $5.00 for non-members. Applicants should include QSL cards or other acceptable proof of contacts (ARRL W.A.S., DXCC, etc.) and return postage.

Oscar Sexagesimal Award

The program for the OSCAR Sexagesimal Award or OSA began in 1976 in response to the many endorsement sticker requests for the basic AOA. To receive the OSA, communication with 60 qualified stations is required. Costs and contact constraints are identical to the easier award. Less than 100 applications are on file for the OSA. The certificate (Fig.3) is printed with black on off-white parchment.

Oscar Century Award

The OSCAR Century Award represents another grade of difficulty beyond the OSA. One hundred qualified contacts via satellite are required for the award. In 1978 the cost was $5.00 for members. Today it is the same as the AOA and OSA, i.e. $3.50 for members and $5.00 for non-members. Less than 20 stations have applied for and received the OCA. The certificate (Fig. 4) is printed with black on off-white parchment with the AMSAT logo in red.

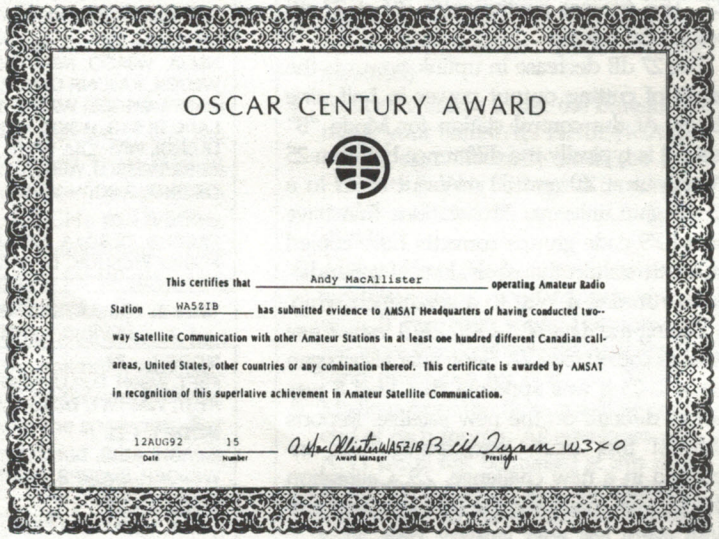
SA AMSAT Satellite Communication Achievement Award

Countries besides the United States promote awards. South Africa AMSAT sponsors their Satellite Communication Achievement Award for making twenty-five two-way contacts through Phase-II satellites. Presently, that would include all RS and Fuji-OSCAR-20 activity. A-O-10 and 13 (Phase-3) contacts are not allowed. The SA AMSAT award is available through AMSAT NA for the usual $3.50 for members and $5.00 for non-members. The certificate (Fig. 5) is signed by SA Awards Manager, Andre Botes, ZS2ACP (ex ZR2FK).

The K2ZRO Memorial Station Engineering Award

The K2ZRO Memorial Station Engineering Award Program, or just "ZRO Test", was begun seven years ago by Vern Riportella WA2LQQ via AMSAT-OSCAR-10. This technical achievement activity via satellite honors the memory of Kaz Deskur, K2ZRO. Kaz was known in satellite circles for his invention of the Satellabe OSCAR tracking calculator and his active participation in hamsat pursuits since the early days of A-O-6. The purpose of the competition is to promote operating skill and receiver performance by testing the listening capabilities of individuals

Figure 5



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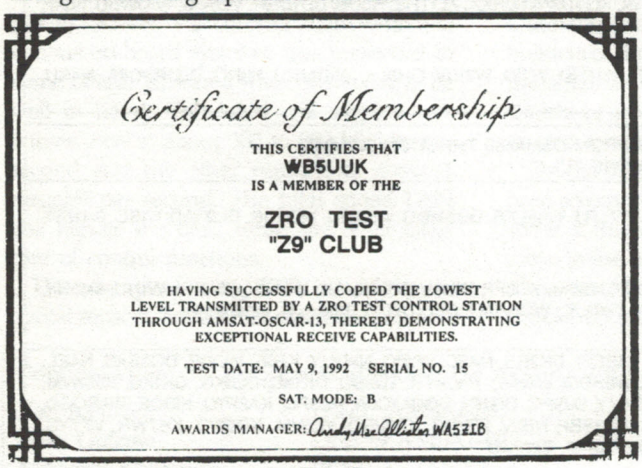

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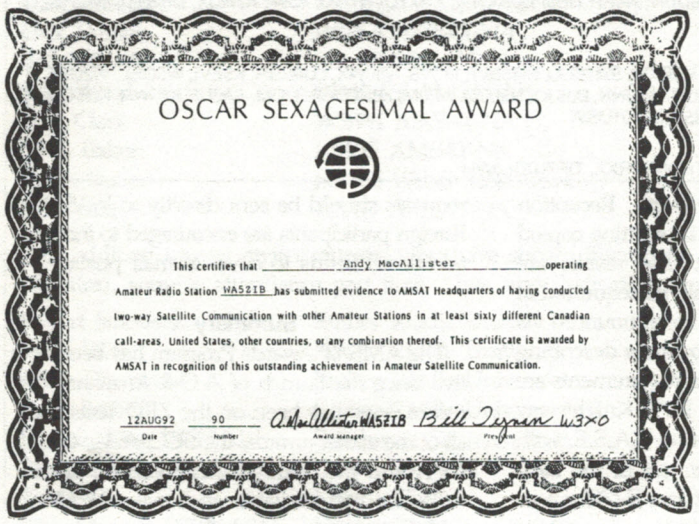

Figure 3

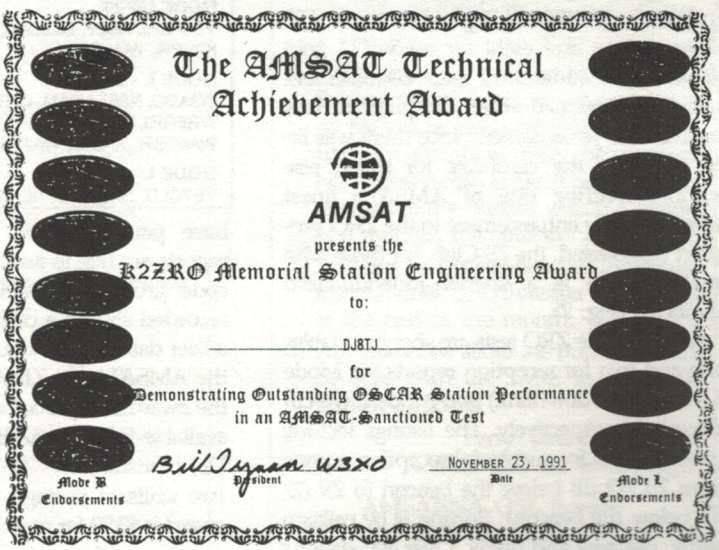

Figure 6

monitoring the transmissions of a control station through the satellite transponder. The program continues today through the mode "B" and "JL" transponders of AMSAT-OSCAR-13. Test coordinators during the last seven years have included WA2LQQ, WA5ZIB, W6HDO and N5EM.

Test sessions are scheduled for periods when the satellite is positioned for optimum spacecraft antenna pointing angles with respect to all earthbound listeners. To provide consistency between tests, the best periods are usually near apogee with the satellite pointed directly at the center of the earth's disc. During a test, which runs approximately 25 minutes, the control station will begin the event by matching his downlink signal to the level of the general beacon. After a short 10-word-per-minute message announcing the test, the numeric code groups begin. A random five-digit number is sent three times at the beacon level, level Z0. The control station will then pause and cut the uplink power in half (-3 dB) for a new random number at level Z1. The process continues to Z9 at 27 dB below the beacon.

The 27 dB decrease in uplink power is the result of cutting output power in half nine times. At the control station for Mode "B" tests, it is typically the difference between 25 Watts out at Z0 and 50 mW out at Z9 to a 13 dB gain antenna. The stations that have heard Z9 code groups correctly have copied an earth station the equivalent of a handie-talkie running a Watt to a seven-inch whip.

During the days of A-O-10 ZRO tests, a few stations copied level Z8. Soon after tests began via A-O-13 it was apparent that level 8 was not as difficult on the new satellite. Reports showed that many participants were interested in a new challenge, Z9. Calibration checks were made and the new level was sent with every test after January 1989.

The ZRO Test certificate is off-white parchment with dark blue printing and the AMSAT logo in red. It has positions for sixteen endorsement stickers, eight for mode "B" silver stickers and eight for mode "L" gold stickers. The addition of a Z9 endorsement was not envisioned when the program was created four years earlier. Since there was little room on the certificate for much else without marring one of AMSAT's finest awards, a new enhancement to the ZRO program was created, the Z9 Club. For those who qualify, there is a special individualized certificate (Fig. 7).

Results of the ZRO tests are shown in tables one and two for reception reports via Mode B (two-meter downlink) and Mode L (70-cm downlink) respectively. The listings include only callsigns for successful reception reports from Z4 (12 dB below the beacon to Z9 (27 dB below the beacon). Sorting is by callsign suffix, call area and prefix. Over 400 stations have participated in the tests. Reception reports are free to anyone submitting copied code groups to WA5ZIB. The results are recorded should a certificate be requested at a later date. Test schedules are announced via the AMSAT nets. ZRO brochures describing the award and participation requirements are available from WA5ZIB at 14714 Knightsway Dr., Houston, TX 77083 for an S.A.S.E. with two units of postage. The cost of the basic award is $3.50 for members and $5.00 for non-members. All reception reports and certificate requests should be sent directly to WA5ZIB. Foreign participants are encouraged to include additional funds to cover airmail postage.

Table 1: RESULTS OF ZRO TESTS FROM 05MAY85 THROUGH 30MAY92
LEVELS 4 THROUGH 9 MODE "B"

MODE B - Z4
DG7AAH, FCIBCU, WQSC, WY0C, NICHM, ON9CHZ, WI6D, KA2DWV, VE7EFF, DHOGMA, W3GYK, PAOHOP, DLIIU, DJ2JJ, DG9MAQ, KB3ML, KI6QE, WA0QJE, AJ9U, WA3YGQ, DG5ZP, M. Bennett

MODE B - Z5
KB6A, VE7AHX, WD4AHZ, WA1AYT, N5BKW, PA3BLY, W9BOZ, N6EEG, DG4FBC, W4FCJ, VE6GK, WB5HLZ, NG1I, DL3IAS, KY7J, K0JAN, K7JRA, WA9KCU, W9KFB, KF7KN, W4KSV, KA9LNV, 4X1MK, IK4MSV, WA3NAN, WA0NZI/HI8, DB7OB, DJ2OQ, KH6OS, WA3PGQ, DD1PI, KO9Q, WB0SMX, NW2T, WA7TSD, AB1U, W5VGF, WB0WAO, WA3WHE, JR8XPV, W5XR, KS8Z, KC3ZG, WA4ZZU, J. Gricci, F. Hahnel

MODE B - Z6
WA9AFM, VKSAGR, PB0AIO, ZL1AOX, OK2AQK, KJ4BF, N2BKT, KE4BM, W0BPP, WB1BRE, DK2BS, K7BZ, KA9CLP, N4CU, N1DBB, DG3DBI, WD0E, DL1EJK, N2EK, KM4EM, N8ENX, W0EOZ, WD6EPV, N3ET, DC6EV, WJ9F, DG6FAL, W7FF, W4FJ, KC5FP, N5FVM, K0GCJ, AB4GK, K2GLS, WA3GPP, DH5HAN, VE3HD, G2HIO, N9HR, PA0HTR, WA1HUM, WC5I, DC7IB, VE3IDJ, WD9IIC, W6ISO, KC7IT, W5IU, WA5IWB, N5JXO, DL5KBG, DK1KC, N6KDY, DD9KE, DK1KQ, WA6LXB, WT0M, WA1MBA, DJ9ME, N4MEY, W6MFO, DG5MHG, K2MPE, DG8NAB, KA9NAH, DG4NAX, DL1NDN, AA6NP, DJ3NY, WZ70, K9OPO, WB30SS, IK6PBX, W8PGP, K6PGT, VE3PQ, K1PXE, KA1QY, WA5RCL, SM3RF, HB9RHV, K8RSP, W0RUE, KB5SA, W6SHP, 9H1SW, AE3T, K4TWJ, W7UAB, DB4UF, KE2UK, DJ0UN, KA3VGD, W3VVP, W2WD, K6WE, KD6WG, VE5XU, W9YCV, K4YYL, ND9Z, WASZIB, K4ZQX, B. Lindholm

MODE B - Z7
VE7AAL, W6ABN, W1AIM, N8AM, VE4AMU, WB9ANQ, W2APU, WA6ARG, KF4AU, G3AUB, DK3AX, KR6B, NI0B, DG7BBX, K0BEJ, PY2BJO, IW1BMJ, K4BQH, SM1BUO, AE1C, I8CVS, NY0D, DL6DBN, WA7DEO, DB8DK, N4DZP, KF6E, WD0EQP, K5EVI, WD4FAB, WB2FCP, WA2FHL, N3FKV, W4FX, DL3GAX, W8GQW, W8GUS, N3GXC, W6HDO, LU1HGN, WA4HHG, KF8HI, W4HJZ, N3HQX, LU 1HUC, SM3JSW, KK3K, PEIKDO, W4KDP, K1KSY, SM0KV, DL6LAU, N4LC, KG6LC, N5LCO, DK2LM, WSLTR, VE7LY, W9MBL, WB6MJN, PY2MSG, W6MSG, KB5MU, K9MWM, WA5MWW, WT0N, WD4NAE, WBONCR, AB4NJ, VP8NO, DL8NP, N4NR, KE7NR, KG5OA, DL3OAG, W3OEJ, AJ9P, WA5PCN, WA7PIB, DG1PJ, AA6PJ, W3PM, SM5PPS, KA8PTQ, KJ4PU, WD8QCN, WA5QGD, DJ5QX, WA1QXR, WA0RGV, W5RRR, WA8RYD, DL9SAD, WA4SBC, DL3SBP, WA4SIR, KA5SMA, KC4SNP, DK5ST, WA4SXM, W6SZ, AF1T, G5TU, DL1TV, DK0UB, WB4ULT, KB7UZ, NB2V, K2VPR, W6VQT, W0WGZ, KE7WR, VE7YC, DL1YDD, DL6YDH, DJ1YQ, WB8YSE/5, W6YVO, DG5ZF, DF4ZK, KA8ZLA, K6ZXE, W0ZZQ

MODE B - Z8
NM3A, W3ADO, N8AI, W5AL, DL5BBL, N5BF, W5BKK, SM5BVF, AA5BY, ON5CD, DL1CF, DL9CI, W0CL, W0DEN, KA5DNP, DFSDP, DG3EAS, LU8EBH, N4EL, N5EM, WB2EMS, N9EP, N0ERC, ICJ9F, N5FD, HB9FD, AA7FV, W5GEL, W2GFF, WB6GFJ, DL3GS, WA4GSS, NJ1H, NU9H, W2HG, W9JI, W8JLE, W4JNN, DJ5JQ, LA1K, DL6KG, W3KH, W7KRC, W8LBC, WB6LLO, DF6LO, VE6LQ, KA1M, W4MFZ, W4MAL, K1MON, K1MYL, DL6NDI, WA5NOM, W1NU, WD40, WB9OEP, AA60J, WA40SR, W8QX, W4RDI, K2RDX, W0ROD, G3RUH, NF6S, KB8S, DG3SCJ, W0SL, DK2SM, W6SYA, KG4TM/WB0RXX, ZL1TRE, N5UB, DD1US/A, VE6VM, WA3WBU, K8XF, OE6XHF, G4XXW, W8ZD, B. Hall

MODE B - Z9
PA2CHR, DLSDAA, N8DUY, PA3EON, K04HD, W7ID, W7KIV, OH5LK, SM1MUU, K9NO, DG1PJ/C6A, N4SU, KC0TO, WB5UUK, DF7IT/DL0WH

Table 2: RESULTS OF ZRO TESTS FROM O5MAY85 THROUGH 30MAY92
LEVELS 4 THROUGH 9 MODE "L"

MODE L - Z4
F9FT, WS0H, DJ2JJ, W3KH, DK2LM, W2LRJ, WA6LXB, DG5MHG, KB5MU, W0RUE, DL9SAD, K1SC, 9H1SW, AE3T, WA5TWT, DB4UF, W1XT

MODE L - Z5
W6ABN, AE1C, DL1CF, DL9CI, KA5DNP, N5EM, KC5FP, WH6I, I5IT, K0JAN, W4KSV, SM0KV, W1NU, DJ3NY, WB9OEP, SM5PPS, W5RRR, K8RSP, DK0UB, WB0WAO, DL1YDD, R. Hoad, B. Lindholm

MODE L - Z6
NM3A, VE7AAL, DL5BBL, DG7BBX, K4BQH, DK2BS, NA5C, WY0C, N8DUY, KF6E, WD0E, DG3EAS, N4EL, WB2EMS, DC6EV, DG5FAL, N3FKV, W6HDO, W4HJZ, PA0HTR, W6ISO, DK1KC, DL6KG, DK1KQ, K9MWM, DL6NDI, N4NR, DH0OAH, AA6OJ, K60YY, DJ9PC, DG1PJ, DG1PJ/C6A, VE3PQ, KA8PTQ, KI6QE, WASQGD, DJ5QX, WA0RGV, HB9RHV, KBSSA, DL3SBP, NB2V, K3VDB, KA3VGD, VE6VM, KD6WG, KE7WR, VE7YC, DL6YDH, K4YYL, ND9Z, KC3ZG, WA5ZIB, M. Bennett

MODE L - Z7
VE4AMU, N5BF, DL5DAA, DL6DBN, N9EP, HB9FD, AA7FV, K1MYL, WD4O, AJ9P, K2RDX, DK2SM, W6SYA, K2VPR, W0WGZ

MODE L - Z8
W3ADO, N8AI, N8AM, DK3AX, N5BKW, SM1BUO, SM5BVF, I8CVS, N8DNX, LU8EBH, K5EVI, W5GEL, W2GFF, WB6GFJ, W8GUS, W2HG, G3IOR, W8JNN, DJ5JQ, N5LCO, WT0M, K9NO, WA5NOM, AA6NP, KE7NR, KG5OA, WA4OSR, AA6PJ, WA7TSD, G5TU, DD1US/A

MODE L - Z9
VE7CLD, DF5DP, W7ID, KG4TM/WB0RXX, DF7IT/DL0WH

Summary

The AMSAT Awards Program has been ac
tive since the launch of A-O-6. Emphasis i
recent years has been on the ZRO Tests, bu
all of the earlier awards, the SCC, AOA, OSA
OCA and the South African version of th
AOA are still available and make excelle
additions to any station.■

Phase 3D Finalized:
(continued from page 1)

By locating the antennas to the motor nozzle side of the spacecraft, they can project farther above the surface - making possible the use of more conventional antennas. For example, S and C bands are now expected to share a dish with a dual band feed. This can be contrasted with the very flat patch arrays which would be required in the original location, on the side opposite the nozzle. One design presented for the C Band patch array involved the use of a nineteen way power divider! The 70 cm antenna will continue to use patches - in this case a six patch array, surrounding the motor nozzle. For 2 meters, three half wave dipoles will be used and 10 meters will employ whips to form a 2 element beam.

Estimated gains for the various bands are:

10 meters	4 dBi
2 meters	8.4 DBic
70 cm	13 dBic
1.2 Ghz	15.5 dBic
2.4 GHz	17 dBic
5.6 GHz	19 dBic
10 GHz	20 dBic

The design architecture for the computers which will control the satellite and handle data, along with the local area network (LAN), which will connect them with the various on-board systems; was presented in some detail. This area was considered to be well in hand. The LAN will employ two busses, one at about 100 to 200 kilobits per second and the other running at about 1 megabit per second. The high speed LAN will handle the data, while the other takes care of control functions.

The concept of using GPS, in addition to optical sensors, for attitude determination was also discussed and found to provide real benefits. A concept of providing a central oscillator to control all receivers and transmitters was also accepted in principle, although it was emphasized that each receiver and transmitter should also provide its own frequency source. Correction is to be applied to the output of the central oscillator to remove the effect of Doppler as the satellite traverses its orbit. It was noted that this would particularly troublesome at 10 GHz. The central oscillator is also to be referenced to GPS to provide very accurate frequency.

The camera experiment, being provided by JAMSAT seems well along. Some prototype hardware has already been produced. Two earth-looking cameras plus another, longer focal length unit, looking out into space are being proposed. It was noted that the camera looking into space may provide the opportunity for doing some interesting astronomy while the others should produce worthwhile wide and narrow angle views of the earth. It was noted that, from the high elliptical orbit which Phase 3D will use, it should be possible to obtain pictures of the northern auroral oval.

The systems which seem the least well along are the RF units. It was stated that the 70 cm transmitter is expected to be built in Germany, but no solid offers from potential builders of the 2 meter, 2.4 GHz and 5.6 GHz transmitters have yet materialized. This should be considered a plea for RF designers to step forward with offers of help.

On the other hand, quite a bit of work has been accomplished on the antennas, although some of this will have to be redone with the move to the nozzle side of the spacecraft. But since more height is now available, the job should be much easier than before.

A proposal was presented and accepted to provide a more formalized scheduling structure using a commercial software package. It was also decided to employ interface documentation much like that used on earlier Phase 3 satellites.

Efforts continue to determine if they, or their organizations, might be interested in participating in the development of Phase 3D.

It was tentatively decided to hold a mini-meeting in Europe, probably in May, with the LAN, GPS and central oscillator the principal topics.■

Principal Phase 3D participants attending the meeting were:

Karl Meinzer	DJ4ZC AMSAT-DL	Germany
Peter Gulzow	DB2OS AMSAT-DL	Germany
Mikiyasu Nakayama	JR1SWB JAMSAT	Japan
Dick Jansson	WD4FAB AMSAT-NA	U.S.
Dick Daniels	W4PUJ AMSAT-NA	U.S.
Bob Stilwell	no call Johns Hopkins Univ.	U.S.
Stan Wood	WA4NFY AMSAT-NA	U.S.
Tom Clark	W3IWI AMSAT-NA	U.S.
Keith Baker	KB1SF AMSAT-NA	U.S.
Ralph Butler	no call Weber State Univ.	U.S.
Bill Tynan	W3XO AMSAT-NA	U.S.

In addition several invited guests, who have shown interest in assisting in the Phase 3D effort, were in attendance part time. They, and their affiliations, are:

Robert Janousek	Embry Riddle Univ.	U.S.
Brian Wolf	Embry Riddle Univ.	U.S.
Chris Edwards	Embry Riddle Univ.	U.S.
Scott Bertin	Embry Riddle Univ.	U.S.
Derwin King W5LUU	Southwest Research Inst.	U.S.
Paul Barrow VE6ATS	Univ of Alberta	Canada
Tim Pratt	Virginia Tech.	U.S.
John Musson WD8MQN	Virginia Tech.	U.S.

AMSAT QSL Bureau

Rules for using the AMSAT OSCAR QSL Bureau.

1. The AMSAT QSL Bureau serves the users of all Amateur Radio Satellites with a complete QSL Bureau for all Amateur Radio satellite contacts (QSLs other than satellite QSOs will be returned).
2. Stations wanting to use the Bureau; arrange your cards ALPHABETICALLY by call sign. Stateside cards are free. However there is a charge of 5 cents per card for all stations outside US Postal districts.
4. Always keep the Bureau informed of any changes in your address or call sign. If you have worked stations using more than one call sign, you should send envelopes for both call signs.
5. Mailings from the Bureau will be at the end of each month. All envelopes with ANY cards will be mailed at this time. The only exception is if the Amateur would like to have his/her envelope held for a certain amount of cards before being mailed. This can be done by writing just below your call sign (in the upper left hand corner) the number of cards desired in the envelope before it is mailed.
6. QSL cards that are received at the Bureau when there are no envelopes on file will be held and the Bureau will make an attempt to notify the user that he/she has cards on file. If no envelopes are sent to the Bureau within a period of 6 months, the *cards will be destroyed!*
7. Mailings for DX stations and individual international QSL Bureaus will go out at the end of the month.
8. Any questions about the Bureau should be sent with an SASE to the QSL Bureau Office.■

Perry Yantis, WB8OTH
AMSAT QSL Bureau Manager

AMSAT-NA QSL Bureau
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Obetz, OH 43207

RUDAK-II on AMSAT OSCAR-21 Full System Overview, Current activities and future planning

By: Peter Guelzow, DB2OS
RUDAK Group, AMSAT-DL

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On 29 January 1991 the first international Orbiting Satellite Carrying Amateur Radio (OSCAR) in which radio amateurs from the Soviet Union worked together with radio amateurs from Germany was successfully launched. The official name of the project was RM1, which stands for "RADIO M-1". The digital transponder RUDAK-2 is part of RM1.

After the launch from the Northern Cosmodrome in Plesetsk, USSR the satellite was named AMSAT-OSCAR 21, to emphasize that the spacecraft was built by, and for, radio amateurs around the world.

Background

OSCAR-21 (RS-14) is a joint project between AMSAT-U and AMSAT-DL. The idea of a joint effort between the two groups, one in the USSR and the other, in Germany first appeared in the spring of 1989. The discussions about what and how things had to be done lasted until the meeting of the representatives of the two groups in Surrey in July 1989 when the preliminary agreement about the cooperation was signed. The final version of the cooperation agreement was signed in the autumn of 1989 after much of the work already had been started.

According to the mutual agreement, AMSAT-U-ORBITA developed and made the linear transponder, receiver, transmitter, command radio link, telemetry system, power supply system and decided all the problems with the official and other government organizations about the location of the equipment and launching.

The RUDAK group of AMSAT-DL developed and made the digital part, called RUDAK-2, which contains a digipeater and an AX.25 mailbox. It also provides other possibilities for experiments in transmitting of information using modern digital methods. It also contains its own RF input and output circuits at the IF level.

The ground command station was developed by the AMSAT-U-ORBITA and AMSAT-U-SPUTNIK groups. The RUDAK group however provided some special digital equipment for it.

Command stations for RM1 are situated in Molodechno at UC1CWA and in Moscow at RK3KP. The ground command stations for Rudak-2 only are situated in Munich at DG2CV and near Hannover, at DB2OS.

The final agreement was signed on behalf of AMSAT-U-ORBITA by the technical director of project "RADIO-M1" - V. Chepyzhenko, RC2CA; and on behalf of AMSAT-DL, by the president, Dr. Karl Meinzer, DJ4ZC. The Project Manager for the RUDAK-2 is Hanspeter Kuhlen, DK1YQ. The coordinators for the project are P. Guelzow, DB2OS and L. Labutin, UA3CR.

The Mission

AMSAT OSCAR-21 is an attached secondary payload (Piggy-back) aboard the USSR geological research satellite "INFORMTR-1" and provides a Mode B communications transponder in low earth orbit and an orbiting experimental digital communications payload, called RUDAK.

The Launch and Orbit

The Launch was originally scheduled for early 1990, but due to some delays on the launcher and the primary payload it was delayed until early 1991. The successful launch on 7 January 1991 placed the satellite into a slightly elliptical polar orbit with about 1000 km height at an inclination of 83 degrees. The period of the orbit is 105 minutes.

Specifications of the Satellite

Dimension and shape: Cylinder of height about 4 meters and diameter 1.8 meters.

System configuration: Professional geological research equipment, telemetry system, command link equipment, transponders and power supply, thermal control. Amateur linear and digital transponders, telemetry system, command link equipment, power supply.

Attitude control: Satellite attitude is maintained using a gravity gradient boom in the form of a rod 9 meters long pointing away from the earth.

Planned service life: 3 years.

OSCAR-21 System specifications

System configuration: Two sets of the equipment are installed aboard the satellite. Linear transponder #1 is Mode B and the RUDAK-2 with subsystems, and a Linear transponder #2 with mode B with subsystems. Transponder #2 does not have any links to the RUDAK-2 subsystem. The Primary transponder is Linear Transponder #1, the second one is a spare which can be put into operation in the event of a failure of the primary system.

Transponder and Beacon Data: The Transponder RF Frequency Assignments and Beacon Data for the Primary Payload are shown in Table 1, those of the backup system in Table 2. The 1100 bps is not a misprint, it is real. Apparently this data rate is used by a popular PC tape cassette interface in the Soviet Union. Because this PC is simple and cheap for the hams in the USSR, the AMSAT-U-ORBITA team decided to use it on this spacecraft.

Antennas: The 435 MHz receiving antenna which is shared by the analog and digital modes is a helix with up to +3 dB gain using Right Hand Circular Polarization. The 145 MHz transmitting antenna is a half wave dipole. Antennas are always earth-pointing due to the satellite's gravity gradient attitude stabilization.

The Telemetry: OSCAR-21 transmits Morse code (CW) and digital telemetry. It will be transmitted on 145.822 MHz when transponder #1 is in use or on 145.948 MHz if transponder #2 is in operation. A CW Morse-Code telemetry frame consists of the call RS14 and 8 channels of four digits in the following format:

RS14	S0AB
	S1AB
	S2AB
	S3AB
	S4AB
	S5AB
	S6AB
	S7AB

Channels 0 to 6 contain analog telemetry data. Channel 7 contains engineering calibration parameters. The first digit (S) identifies some special status information for the command stations. The second digit (0 to 7) is the number of the line (channel). The remaining digits (A and B) are the analog telemetry data which can be decoded according to the equations shown in Table 3.

Table 1:	Primary Payload	
Beacons and telemetry #1		
CW telemetry 8 channels	145.822 MHz	0.2 Watts
Digital telemetry 30 channels	145.952 MHz	0.4 Watts
	1100 bps, PSK/FM, deviation 2kHz	
Digital telemetry Rudak-2	145.983 MHz	3.0 Watts
	BPSK 1200 bps AX.25 (like FO-20)	
Transponders #1		
Linear transponder: inversely heterodyned translator		
Uplink passband	435.102 to 435.022 MHz	
Downlink passband	145.852 to 145.932 MHz	
Transmitter output max	10 Watts	
Bandwidth (3db)	80 KHz	
Uplink EIRP required about	100 Watts	

(2) Digital transponder Rudak-2: digipeater and store & forward packet communication (AX.25), telecommunications experiment with digital signal processing up to nearly 20 kHz, 1 MByte RAM disc, four separate uplink channels.

Uplink frequencies:

RX-1	435.016 MHz	1200bps,FSK,NRZIC/Biphase-M
RX-2	435.155 MHz	(AFC) 2400 bps,BPSK, Biphase-S
RX-3a	435.193 MHz	(AFC) 4800 bps,RSM
RX-3b	435.193 MHz	(AFC) 9600 bps,RSM
RX-4	435.041 MHz	(digital AFC) RX for RTX-DSP

Downlink frequency: 145.983 MHz 3 Watts

The downlink can be switched to the following operating modes:

Mode 1: 1200 bps, BPSK, NRZI,(NRZ-S) (like FO-20)
Mode 2: 400 bps, BPSK, Biphase-S (Like A0-13 beacon)
Mode 3: 2400 bps, BPSK, Biphase-S
Mode 4: 4800 bps, RSM, NRZIC (Biphase-M) (like 4800 bps uplink)
Mode 5: 9600 bps, RSM, NRZI (NRZ-S) +Scrambler (like 9600 bps uplink)
Mode 6: CW keying (only for special events)
Mode 7: FSK (F1 or F2B),e.g. RTTY, SSTV, FAX, etc. (for special events)
Mode 8: FM modulated by D/A signals from DSP-RISC processor (speech)

Table 2:	Secondary Payload	
Beacons and telemetry #2		
CW telemetry 8 channels	145.948 MHz	0.2 Watts
Digital telemetry 30 channels	145.838 MHz	0.4 Watts
	1100 bps, BPSK/FM, deviation 2 kHz	
Digital telemetry 30 channels	145.800 MHz	2.0 Watts
	1100 bps BPSK/FM, deviation 2 kHz	
Transponder #2		
Linear transponder: inversely heterodyned translator		
Uplink passband	435.123 to 435.043 MHz	
Downlink frequencies	145.866 to 145.946 MHz	
Transmitter output max	10 Watt max.	
Bandwidth (3db)	80 kHz	
Uplink EIRP required about	100 Watts	

Digital Telemetry (RM1): The Digital telemetry consists of 30 parameters monitoring on-board conditions and two calibration verification points. It is generated by the transponder payload and command system and not by the RUDAK-2 system. The transmission baud rate is 1100 Bit/s with FM/PSK Modulat ion. The beacon frequency is 145,952 MHz for transponder #1 and 145.838 MHz for transponder #2. If transponder #2 passband is off, then the digital telemetry beacon operates on 145.800 MHz.

The RUDAK-2 digital communications payload

The Computers: RUDAK-2 contains two computers. The first, called R1, is a slightly modified version of the RUDAK computer originally developed for OSCAR-13 in which mainly digipeater operation had been intended requiring relatively little memory capacity. For that reason the computer was only equipped with 56 kByte of RAM. On account of the low orbital altitude of OSCAR-21, mere digipeater operation is not particularly exciting, thus leading to the decision to support mailbox and store & forward operation also. However, since the 56 kBytes of memory are not sufficient to store the entire software, RUDAK-2 also has a 1 MByte memory expansion which is serially accessible in 256 byte blocks via an 8 bit port. Since it is operated similar to a disk drive, it is called a RAM disk. This system, although functionally complete already, was extended further by the addition of a second computer. The design of R1 is approximately five years old and thus no longer corresponds to the current state of technology. A more modern computer concept was developed in order to provide for a certain degree of redundancy and also to allow the evaluation of newer more exciting techniques particularly in view of Phase 3D. The name "RUDAK Technology Experiment" (RTX) reflects the experimental character of this system. The most interesting aspect will probably be the unprecedented use of digital signal processing. In addition to two or four phase PSK, other modulation types such as rectangular spectrum modulation (RSM), minimum shift keying (MSK) or even FSK could be tried out. Furthermore, it is conceivable to improve the signal to noise ratio by use of encoded modulation types such as "folding codes" in conjunction with Viterbi AND/OR soft decision decoding.

The entire system was so conceived that a failure of any one of the three subsystems (R1, RAMDISK, RTX) would still permit acceptable operation.

The R1 Computer: R1 is a typical representative of the 8-bit microcomputer generation. A 65SC02 C PU clocked at 819.2 kHz, serial (84C40 SIO) and parallel (65SC22 VIA) interface components, as well as seven 8-kByte CMOS RAM's (4464 with 6 transistor cells) and one 8 kByte CMOS PROM (6616) constitute the nucleus of this computer. Along with all other necessary logic components, the total count of IC's is a mere 22. Since a standby reserve had been allocated during the development of the RUDAK processor for OSCAR-13, this second board could thus be used directly in RUDAK-2. Only the parallel port needed modification to support bidirectional operation of the RAM disk.

The RTX Computer: To a certain degree, this computer originated from the goal of evaluating as many alternatives to the R1 concept as possible. Since reliable operation is possible even without a second computer, lower safety margins were accepted than for

RI. The RTX employs the 16 bit RISC CPU RTX-2000 from Harris Corporation. It can be run optionally at 9.8 MHz or 6.5 MHz with one memory access per clock cycle. At the faster rate, it reaches a throughput of typically 10 to 15 MIPS (millions of instructions per second), with a maximum of 40 MIPS. The architecture of the CPU diverges significantly from that of conventional microprocessors and corresponds to the virtual CPU of the programming language FORTH. For a number of reasons, the CPU is particularly suitable for our intended application:

- The FORTH architecture supports the implementation of IPS, i.e. the CPU uses IPS essentially as its machine language, thus permitting extensions to the available IPS software, but at execution speeds higher by at least a factor of 100.
- The short execution times for instructions (1 or 2 clock cycles no pipeline) allows very rapid interrupt processing.
- The rapid multiplier simplifies digital signal processing (DSP).

However, at the beginning of development, the group had no practical experience with this relatively new CPU. The main memory of the computer consists of 128 kBytes of RAM (65536 16 bit words). Static CMOS RAMs with access times of 35 ns were chosen due to the high access speeds required. In contrast to RI, this memory is equipped with a 1 bit error correction logic in order to catch any probable soft errors. The error correction logic requires an additional 65 kBytes overhead so that a total of 192 kBytes of memory is installed. The RTX computer contains no fixed program storage (PROM) since this may have been the cause of the failure of RUDAK-1. The operational software is loaded via direct memory access (DMA) in the same manner as for the onboard computer of the Phase 3 satellites (IHU).

The input/output section constitutes a significant portion of the system. VLSI components such as an SIO were not chosen since most standard IC's cannot handle the high bus speeds. These functions were shifted to the software.

All 14 digital inputs are connected to the receivers and diverse telemetry signals. Four digital outputs control the transmitter and the RAM disk. Two bidirectional 8 bit ports provide the link to R1 and the RAM disk. If the RTX is switched off, this 8 bit port goes transparent so that R1 and the RAM disk can communicate. In all, there are 16 inputs and 2 outputs in the analog interface of the computer. Two of the inputs receive the demodulated orthogonal components I and Q from the receiver Rx-4. One output drives the VCO of this receiver. In this way, various coherent and of course non-coherent demodulators are possible using digital signal processing. Limits are set only by the computational capacity of the CPU and the IF bandwidth in the receiver.

An additional input gets the discriminator output from Rx-1 and thus supports demodulation of FM signals or the evaluation of analog signals such as speech. The remaining analog inputs get analog telemetry signals. The second output allows analog frequency modulation of the downlink.

The circuit consisting of 63 IC's was laid out on a four layer circuit board, two for power and two for signals. The relatively large number of IC's is due in part to the discrete construction of the I/0 section and the lack of "trick circuits", which were avoided because of the tight time schedule with 3 1/2 weeks for circuit design, 2 weeks for board layout, and 2 weeks for board construction, so that no prototype could be built. It was thus indeed a big relief when the circuit, which had been developed entirely on paper and computer monitor, functioned perfectly the first time.

The power consumption of the computer during operation is around 1.5 Watts, most of which is needed by the fast RAM's.

The RAM Disk: The memory expansion for the mailbox contains 31 static 32 kByte CMOS RAMs without error correction. If it should prove to be necessary, error correction can be implemented in software. In place of the 32nd RAM, an EPROM was installed, half of which was programmed at "fast" and half at "normal" rates. Due to the increased radiation in orbit, the EPROM should be erased more or less quickly. The goal of this experiment is to measure this lifetime in conjunction with the programming algorithm.

The RAM disk is not mapped into the main memory, but is accessed as a peripheral device via the parallel port. The memory is divided into blocks or sectors of 256 bytes each, similar to disk devices. The data within a block can thus only be read or written as a whole. Although the RAM disk should primarily serve the mailbox, other applications are also conceivable, such as intermediate storage of programs or digitized analog data. The power consumption of the RAM disk is a mere 30 mW.

The Transmitter and Receiver: The transmitter was so designed that, in addition to the "old" data rate of 400 bits/s PSK, it can be operated with data rates up to 9600 bits/s. However, the normal mode of operation will be 1200 bits/s and the 400 bits/s will likely only be used during initial testing and startup. Furthermore, the possibility of generating frequency modulation was provided so that even FSK or Analog FM can be transmitted.

Four receivers are provided for reception of signals from ground stations: Rx-1 receives 1200 bits/s FSK and Rx-2 receives 2400 bits/s PSK. These two receivers support the routine operation of RUDAK-2. The two other receivers are more of an experimental nature. Rx-3 receives 4800 bits/s or 9600 bits/s RSM. Rx-4 is similar in design to Rx-3, but the necessary filters are implemented in software for a special processor, the RTX, which will be operated as a signal processor. Thus it will be possible to receive virtually any type of modulation for experimentation.

For the first time, RUDAK-2 provides the opportunity to evaluate RSM in outer space in anticipation of Phase 3D. At 1200 bits/s FSK, transmitter power of 10 W is required with 5 dBi antenna gain. At 9600 bits/s RSM the necessary power increases to 20 W. Naturally, antennas with higher gain could also be used, reducing the needed power correspondingly.

Table 3: CW Telemetry decoding parameters

Channel (line)	Parameter	Formula	Unit
0	Transponder power output	0.05N	Watt
1	Transponder PA Temperature	N	Deg. C
2	+ 24 V Regulated	N	Volt
3	+ 16 V Regulated	N	Volt
4	+9 V Regulated	N	Volt
5	Service	N	*
6	Service	N	*
7	Service	N	*

For example, a typical frame and its meaning is shown below.

RS14	7059	-2.95 Watt HF
	7124	-24 deg. Celsius PA temp.
	7224	-24 Volt Power Supply Voltage
	7316	16 Volt Power Supply Voltage
	7410	9 Volt Power Supply Voltage
	7500	internal status
	7600	internal status
	77PP	internal status

First experiences

The RUDAK-II payload was successfully switched ON for the first time nearly one

(continued on page 23)

Spotlight On: KITSAT-OSCAR-23

[This article is the latest in a continuing series of articles on currently active Amateur Radio satellites. In this issue of The AMSAT Journal, KD2BD shines the spotlight on KITSAT-OSCAR-23.]

By John A. Magliacane, KD2BD
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UUCP : ...catfish.ocpt.ccur.com!ka2qhd!kd2bd
Packet : KD2BD @ NN2Z.NJ.USA.NA
Internet: kd2bd@ka2qhd.de.com -or-
kd2bd@amsat.org

KITSAT-OSCAR-23 is an enhanced version of the UoSAT-OSCAR-22 spacecraft. It was built by engineers of the Korean Advanced Institute of Science and Technology (KAIST) after participating in a Masters degree course in Satellites and Telecommunications held at the University of Surrey in England. KITSAT-OSCAR-23 carries several payloads, including a high resolution Earth Imaging Camera System, a Digital Signal Processing Experiment, a Cosmic Ray Experiment, and a 9600 bps AX.25 protocol store-and-forward PACSAT Communications System.

KITSAT-OSCAR-23 was launched from French Guiana, South America last year as a secondary payload on the Ariane V-52 mission. The satellite is in a circular orbit with an inclination of 66 degrees and a mean altitude of 1300 km. The orbit is not sun-synchronous, however. Not only does KITSAT's orbit differ from most previous OSCAR satellites, but its launch itself was not free. The 66 degree inclination tends to favor service to the mid-latitude areas of the world. KITSAT's orbital precession does not track with the Earth's terminator, so passes do not occur around the same time of day after local sunrise or after sunset as is the case with the MicroSat satellites and other satellites in sun-synchronous orbits.

KITSAT-OSCAR-23 Payloads

The PACSAT Communications System (PCS) carried on KITSAT-OSCAR-23 is identical to the digital store-and-forward communications system carried on UoSAT-OSCAR-22. KITSAT's PCS carries 16 Megabytes of RAM, operates in Mode JD at 9600 bps, and can be accessed with the same groundstation equipment as that used to access UO-22. The PCS mailbox uses two uplink frequencies in the 2-Meter band, which work into a single downlink channel on 70-cm. The data rates of all the digital radio links is 9600 bps.

KITSAT's Earth Imaging System (EIS) camera has two monochrome charge coupled device (CCD) imagers. One acts as a "spotting camera" with a wide-angle lens having a resolution of 3500 meters, while the second uses a telephoto lens for a resolution down to 400 meters. Groundstations equipped for reception of UO-22 CCD images can receive KITSAT images without modification. JPEG image compression is also possible with the imaging hardware and software capabilities of the satellite. The images returned from KITSAT so far are truly spectacular. NK6K has converted many of these images to the Graphical Interchange Format (GIF), and has made them available on the Compuserve Hamnet Library.

The Digital Signal Processing Experiment (DSPE) uses TMS320C30 and TMS320C25 DSP chips for modulation experiments involving 19,200 bps data links, real-time speech, stored speech, spoken telemetry, and ultimately, 38,400 bps radio links. Unfortunately, the DSP chips consume a lot of power, so DSPE operations are fairly limited in duration. The speech capability of the DSPE experiment has already been tested, and can be used to transmit multilingual greetings and news bulletins. Low-cost 70-cm recievers are currently under development in an effort to make reception of KITSAT-OSCAR-23's voice messages simple and inexpensive. Digitized voice repeater functions are also possible with the DSPE hardware carried on KITSAT. DSPE testing and experimentation will be used to provide insight into the usefulness and effectiveness of incorporating DSP transponders in the design of AMSAT's Phase 3D spacecraft.

The Cosmic Ray Experiment (CRE) measures KITSAT's total radiation dose and its susceptibility to damaging cosmic rays. The information gathered from this experiment will be used in designing future OSCAR satellites for the rigors of space. KITSAT's 1300 km altitude orbit places the satellite in the lower regions of the Van Allen radiation belt where it is subjected to a good deal of radiation. Damage from high energetic radiation particles is expected to limit the operational lifetime of KITSAT to only about three to five years.

KITSAT-OSCAR-23 Operations

KITSAT-OSCAR-23 operates in "Mode J" with a primary uplink on 145.850 MHz and a secondary uplink on 145.900 MHz. A single downlink transmits on a frequency of 435.175 MHz. 9600 bps FSK modulations is used on all radio links, with the exception of the periods of time when the DSPE experiment is active when higher baud rates and different modulation formats (including FM voice) may be used. The standard AX.25 packet radio protocol is used on KITSAT-OSCAR-23, as it is with UoSAT-OSCAR-22, Fuji-OSCAR-20, AMSAT-OSCAR-21 and the MicroSat satellites.

Summary

KITSAT-OSCAR-23 is not only providing packet radio store-and-forward communications service to OSCAR groundstations worldwide, but is also returning some of the best Earth images ever taken by an OSCAR satellite.

A new KITSAT satellite is currently under construction by the Korean Advanced Institute of Science and Technology. KITSAT-B will be similar to KITSAT-OSCAR-23, but will also carry a GPS receiver, and is expected to be launched later this year with SPOT-3, but only after the current SPOT-2 satellite requires replacement. This launch will not only carry KITSAT-B, but also the Italian ITAMSAT Amateur satellite, and two Portuguese Amateur satellits into an orbit similar to that of the current MicroSats.■

TABLE 1

KITSAT-OSCAR-23	Catalog Number: 22077	
Uplinks:	145.850 MHz	9600 bps FSK, AX.25 (Primary)
	145.900 MHz	9600 bps FSK, AX.25 (Secondary)
Downlinks:	435.175 MHz	9600 bps FSK, AX.25, FM Voice, DSPE Output

AMSAT Phase 3D Antenna Design Review
Phase 3D HF/UHF/Microwave Antennas

By: Stan Wood, WA4NFY, and Dick Jansson, WD4FAB

[This article first appeared in the Proceeding of the Tenth Amsat-NA Space Symposium, October 9-11, 1992, Washington, DC]

The AMSAT Phase 3D satellite is looking more and more like an Orbiting Antenna Farm. The satellite will have antennas for seven of the eleven of the Amateur communications bands from 0.029 GHz to 10.5 GHz. For the antenna designer, it is quite a chore trying to find antenna designs for all of these bands, and to find space on the satellite to place all of them. There are at least two serious efforts underway to find the most suitable antennas for this application. This report covers the results one of these efforts.

Spacecraft Limitations

Fig. 1 shows a generalized perspective view of the Phase 3D spacecraft. The principal radiation direction is along the +Z axis, the center line of conical adapter, toward the top of the illustration. On the Phase 3D satellite we have the entire top surface available for RF capture area, a fact that has not gone unnoticed. While there is a lot of surface area on the top of the spacecraft, there is almost no available height. A limitation of 50 mm (2") in height above the +Z surface of the spacecraft is dictated by the close spacing of P3D and the Cluster Spacecraft. Any antenna dimensions in the +Z direction will need to be less than 50 mm above the spacecraft bus structure. In other words, low profile antenna designs are needed. Deployable antennas are limited to flexible whips for high reliability.

Orbit Parameters

The launch of AMSAT P3D into an initial transfer orbit and it's final placement into a 16-hour Molnia orbit places multiple requirements on the antenna system. See figure 2. Initially P3D will be spun on the Z axis to maintain stability for motor firing. The Z axis will be oriented 90 to the major axis of the orbit and in line with the plane of the orbit. Table 1 shows the link variables encountered in this orbit.

Omni Antennas

While the spacecraft is spinning Omni Directional antennas are required.

Several Omni Directional antennas were evaluated. Fig. 3 is the Omni Antenna used on Oscar-13. It is a two band vertical operating as a 1/4 wave whip on 145 MHz and a 1/2 wave J-Pole on 435 MHz. The antenna is fed at the base of the longer element with a simple duplexer and matching unit. Fig. 4 shows the expected pattern from such an antenna. Max gain is 2.5 Dbi perpendicular to the Z-axis with a deep overhead null. The main problem with this antenna is finding a suitable mounting point were it produces a usable antenna pattern.

Table 1: AMSAT P3D Orbit Parameters

Orbit hr	Phase	Range	Path Loss	Z axis	<Earth<
8 hr	128	49800 km	-185.5 db	90 deg	13.0°
7 hr	112	48900 km	-185.4 db	80 deg	13.5°
6 hr	96	46600 km	-185.0 db	74 deg	14.5°
5 hr	80	43000 km	-184.3 db	67 deg	15.0°
4 hr	64	38000 km	-183.2 db	59 deg	17.0°
3 hr	48	31500 km	-182.6 db	47 deg	20.0°
2 hr	32	23700 km	-180.2 db	28 deg	25.5°
1 hr	16	15800 km	-177.9 db	15 deg	38.5°
0 hr	0	5000 km	-165.5 db	90 deg	68.0°

This table shows the orbital Time, Phase, Range, Path Loss at 1269 MHz, the angle between the Z axis and the Earth (Z axis<), and the width of the Earth as seen from the spacecraft (Earth<). The maximum pathloss at 1.2 GHz is -185.5 dB at apogee (Phase 128) with a minimum pathloss of-165.5 dB at perigee (Phase 0). The path loss varies 20 dB on ALL Frequencies over an entire orbit.

Fig. 5 is a pair of Turnstiles stacked 1/2 wave length apart and mounted 1/4 wavelength above the spacecraft. This antenna has the same gain (fig.6) as the vertical ant with an overhead null of -18 db. With the 20 db change in pathloss encountered in the P3D orbit a more constant signal level is maintained. There is not sufficient height above the spacecraft (+Z surface) to mount this antenna. But it could be mounted on the bottom (-Z surface) for the higher frequency bands. Computer models of this antenna showed far less distortion of the antenna pattern caused by the spacecraft structure. Further work on the antenna test range is required to verify this result.

Final Orbit

When the spacecraft reaches the final orbit it will be despun and three axis stabilized using momentum wheels and magnetic torquing. The solar panels will be deployed increasing the power available by a factor of three. The spacecraft will rotate to point the +Z surface at the Earth for the entire orbit. All high gain antennas are fixed in the + Z direction. Antenna pointing is done by positioning the entire spacecraft during the orbit so that the high gain antennas can be used continuously.

To properly illuminate the Earth during the final orbit, selectable gain antennas are recommended. At apogee the width of the Earth as viewed from the spacecraft is 13°. This limits the maximum gain of the antennas to 19 dBi, as higher gains would have too narrow a beamwidth and not allow full illumination of the entire Earth. At perigee the width of the Earth is 68° and the maximum gain is 6 dBi for full illumination. A variable gain antenna with a range of 6 to 19 dBi would

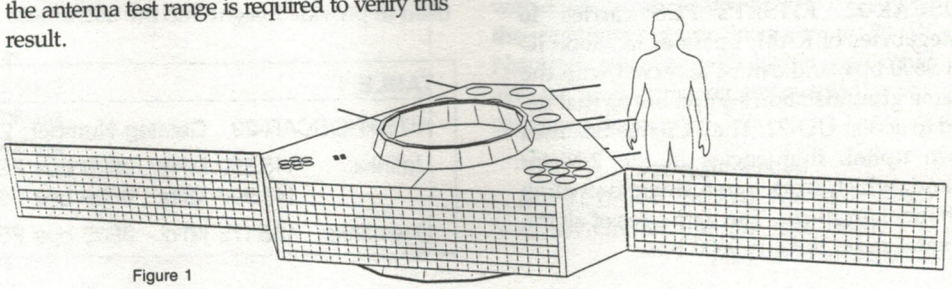
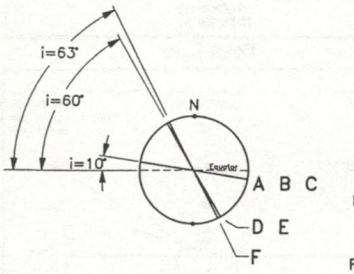


Figure 1

	Motor Burn	Orbit	Incli-nation	Distance, from Earth (km) Perigee	Apogee
1.		A	i=10°	200	35000
2.	in Apog.				
3.		B	i=10°	500	35000
4.	in Perig.				
5.		C	i=10°	500	47000
6.	in Apog.				
7.		D	i=60°	4000	47000
8.		Drift without Motor Burn			
9.		E	i=60°	4000	47000
10.	in Apog.				
11.		F	i=63,4° Stable Orbit	4000	47000



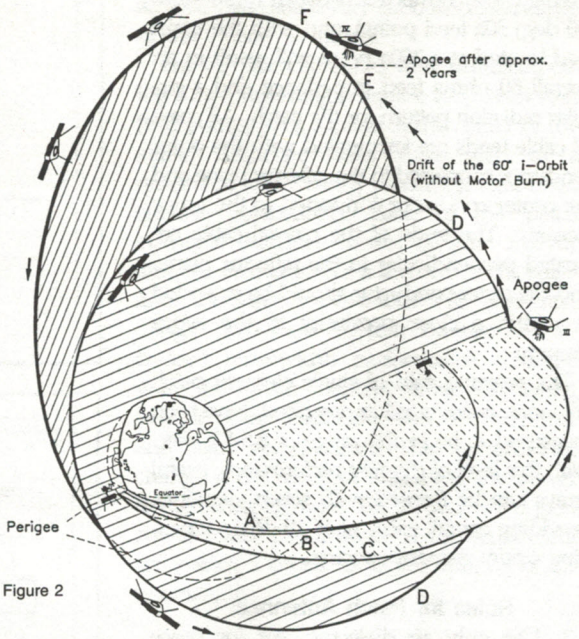


Figure 2

give optimum performance for the entire orbit. The effect of the 20 dB change in path loss would be reduced to only a 7 dB change. This variable gain operation does not mean that an absolutely uniform illumination of the Earth needs to be obtained at perigee, only that the signal at receivers on the illumination limb of the Earth will be no lower than the signal levels seen with the satellite is at apogee. The antenna arrays shown in Fig. 1 will meet that objective and will be described.

High Gain Antennas

While we cannot pretend to have examined every possibility for all of the antennas needed, the list is significant. For 29.4 MHz the choices were rather limited. As this is also a limited use beacon mode operation, the antenna does not need to be exotic, and the considerations have included a three pole CP "XBeam" and a "dipole" consisting of gamma matching the solar panels as the dipole elements. Computer models showed a two element "X Beam" mounted on the end panel of the rear arm of the spacecraft to give the best results with a minimum amount of interference with other antenna arrays.

The proposed antenna (fig.7+8)is basically a linear polarized two element narrow spaced beam, using a dipole as the driven element and a single director. The director is mounted near the top center of the rear end panel and the driven element near the bottom center of the rear end panel. This gives a spacing between elements of 650 mm which is the height of the spacecraft bus. The element spacing is effectively increased by canting the director elements up 15 degrees and the driven elements down 15 degrees. This increases the input impedance and bandwidth of the antenna. All the elements were then swept back 30 degrees from the spacecraft to reduce interference with solar panel deployment and other antenna arrays. The antenna's computed gain of 6.5 is sufficient for operation in the lower half of the proposed P3D Orbit.

Another band that has proven to be troublesome is 145.9 MHz. The selections are also limited. The top surface of the spacecraft cannot be totally used for just this band. The first solution (Fig. ?) was a single circular polarized full wavelength loop antenna mounted in the middle of the open throat of the conical adapter with six 1/4 wavelength three element beam antennas that extend from the sides of the spacecraft. The beams (Fig. 9) are mounted 1/2 wavelength apart on the radiator panels and the front solar panel. The elements on the radiator panels are made of flexible steel tape, while the solar panel elements use 1.5 mm music wire to minimize shadows on the solar cells. Fig. 10 shows the pattern of one side of the spacecraft. Variable beamwidth performance came from varying the power ratio between the center loop a the center loop antenna.

An alternative antenna for 145 MHz is shown in Fig. 13. The antenna is made up of six end-fed 1/2 wavelength dipoles radiating from near the top of the conical adapter. Computer models show a gain of 10 to 12 dBic (Fig. 14) and a very symmetrical pattern. This antenna is usable through the entire orbit with no gain changes required. We just turn on the transponder and let it run. Figure 16 is a computer generated figure of the antenna pattern projected on the earth with the satellite at perigee. The gain on the Lem (edge) of the earth is .83 dBic. With the decrease in path-loss this results in a 11 to 20 dBic in signal level for ALL STATIONS from apogee to perigee. While not shown the gain directly below the spacecraft is 10 to 12 dBic. Figure 16 is a model of the first antenna at perigee and still set for maximum gain. The gain at the Lem of the earth varies from 6.5 to -25 dBic. The first antenna requires at least two gain levels to operate through the entire orbit.

For the higher bands the antenna situation becomes considerably easier, as the area available is quite adequate for some really good performance. The considerations have been patches, turnstiles, recessed turnstiles, slots, and short circular horns. The trade offs for this list is complex, but we have concentrated on the most attractive of the bunch, the patch antenna. The 10.5 GHz band will clearly use waveguide horn antennas directly connected to their transmitters.

The Patch Antenna

Patch antennas can be described as a thin square sheet of conductor material, approximately 1/2 wavelength on a side, closely spaced above a larger reflector plane. The center point of this active element may be grounded using a vertical conductor. While not exact, this patch radiator can be thought of as a pair of slots, spaced by 1/2 wavelength and backed by a reflector. Element feed points can be from an edge, or inward with corresponding impedance variations. Patch antenna active elements may be of almost any shape, including round, rather than square. When properly feed, patch antennas operate with good circular polarization (CP) radiation performance. In the CP operation, all edges of the patch are active.

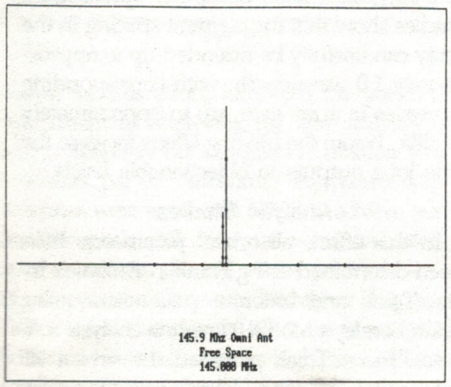


Figure 3

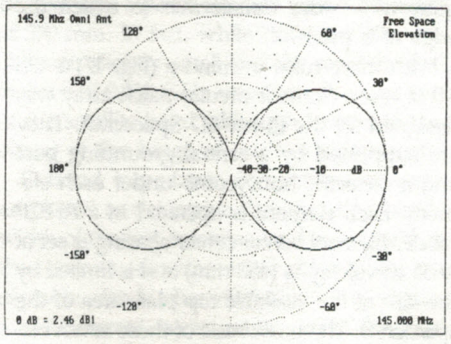


Figure 4

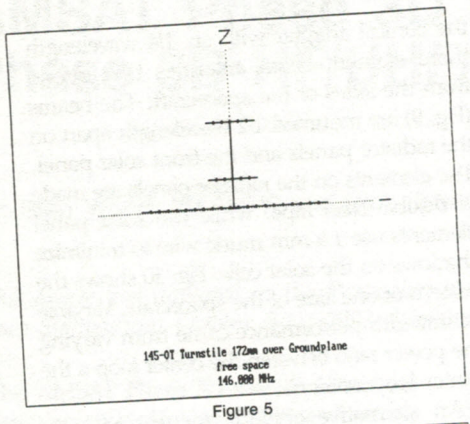


Figure 5

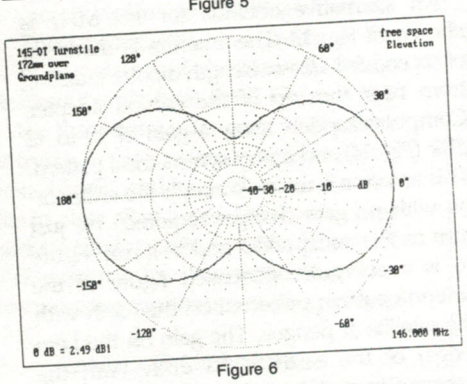


Figure 6

When antenna users come in contact with the patch antenna, it is often those versions constructed with printed circuit board (PCB) materials and employing microstrip feed techniques. While such methods permit some rather impressive arrays to be constructed, the efficiencies encountered are often as low as 50%, principally due to dielectric losses and reduced element size caused by the material dielectric constant. Patch antennas do not need to employ high dielectric materials in their construction, and we will use air (or space vacuum) as the dielectric.

Our tests have shown that the construction of these patch antennas requires some careful attention to fabrication methods and dimensional details. We have found that square patch active elements need to be approximately .47 wavelength on each side, while the round versions are .54 wavelength in diameter. Close control of element size is important. Another important dimension is that of the spacing of the element from the reflector, ~ 0.01 wavelength. Spacings of less than 0.01 wavelength result in reduced efficiency. Our need to carefully control the spacing is causing us to seriously consider the use of some repeatable spacing media, such as an open cell low dielectric constant honeycomb material.

With the construction methods being employed, the feed impedance characteristics are somewhat different than those of the PCB microstrip antennas. 50a feedpoints have been found to be located at 0.078 wavelength from the center, while a 100 ohms feedpoint is located at O.115 wavelength from the center. These are good dimensions to know, as a simple 1/4 wavelength coupling line of UG141 coaxial cable connected between quadrature (90 deg) 50a feed points, and with the main feed located at a 100a point will result in an overall 50 ohms feed impedance and a circular radiation pattern for the patch. All coaxial cable feeds are terminated with the outer conductor connected to the reflector plane and the center conductor connected to the active element. The ends of the coaxial cable are located perpendicular to the reflector plane, and the outer conductor should be extended to within a close proximity to the active element.

The antenna gain of single element patch antennas, constructed as described, have been measured to be in the range of 8.5-8.8 dBic. With this level of element performance, useful arrays can be formed with seven elements, providing overall gains of 16-19 dBic, depending upon element spacing.

Rules for Patch Antennas:

1. Use only air dielectric. Air (or space vacuum) has the lowest loss and a dielectric value of unity. A dielectric constant, e = 1.0, makes the patch element full size which gives maximum gain. Teflon with a e =2.45 reduces the size to 64% and with no loss reduces the maximum gain by 3 dB. This is caused by the wider beam width of the smaller patch.

2. Mount patch higher not lower. The height of the patch above the groundplane should be approximately two percent of the width of the patch. With air dielectric a half wave square patch should be a minimum 0.01 wavelengths above the groundplane. Lower heights result in higher Q and high currents resulting in higher losses.

3. Design for maximum bandwidth. The bandwidth of a patch antenna is direct function of it's height. The limiting factor is mutual H-plane coupling in a close spaced planner array. The higher the elements the greater the spacing required between elements. Minimum edge spacing for 20 dB isolation between elements is 0.12 wavelength for a height of 0.04 wavelength.

4. Use coaxial not stripline feed. Patch antennas and striplines are not efficient on the same dielectric material. Strip lines prefer a high dielectric substrate and minimum height to work properly. 50 ohm strip lines also require a ~ wave transformer to match the edge of a patch.

With these rules in mind a (Fig. 17) a 435 MHz seven element circular patch array was designed for the Phase 3D Spacecraft. They are supported by a central grounding post and a dielectric honeycomb under each element. Each element is operated in a RHCP mode. Element center-center spacing is set at 0.655 wavelengths (450 mm) and is limited by the size of the available top plate area of the spacecraft. The most basic of these seven element arrays is a hexagonal pattern with the seventh element in the center of the array. The

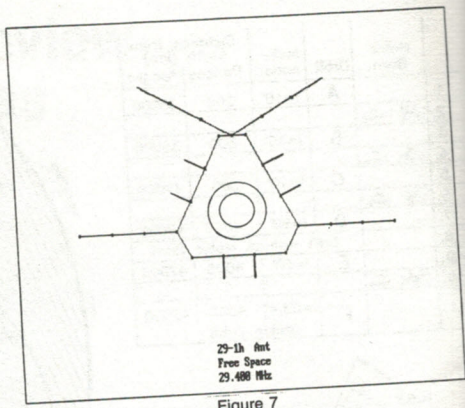


Figure 7

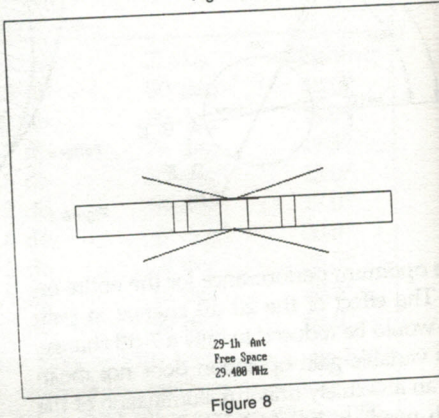


Figure 8

power to the center elementis varied to c trol the gain of the array. With equal pow to all elements, the array is set for maxim gain. With the center element running m imum power and the outer elements ru ing minimum power the array is at minim gain and maximum beam width. Comp models show a continuously variable range of 8.5-14 dBic by only changing power to the elements. All elements are in phase and no phase changes are requ

The patch array for 0.435 GHz need have two of its elements repositioned to it to be fitted to the top of the spacecra shown in Fig. 1. While this variant o seven element array does change the o performance, the deviation is on the orc 0.5 dB, mainly in the azimuth uniform the pattern.

For the higher bands, the fully opti seven element patch array can be emp as the space occupied is not too dema of the available area. Computer optimi studies show that the element spacing array can usefully be extended up to a imately 1.0 wavelength, with corresp increases in array gain, up to approxi 19 dBic, before the fringing effects incre side lobe outputs to objectionable le

Analytic Studies:

In this effort, all orbital paramete been determined using Franklin Anto stantTrack and antenna parameter Brian Beezley's MNC4.0 antenna analy ware. InstantTrack provided the or range, path losses and Earth size info We have found that the MNC analy

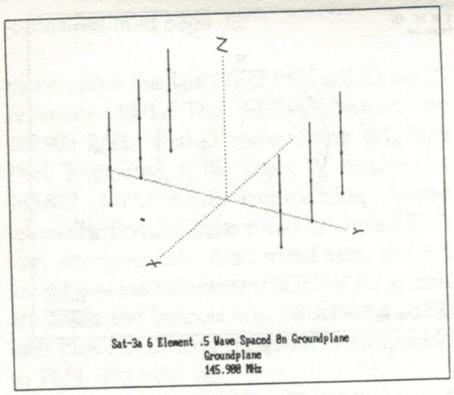


Figure 9

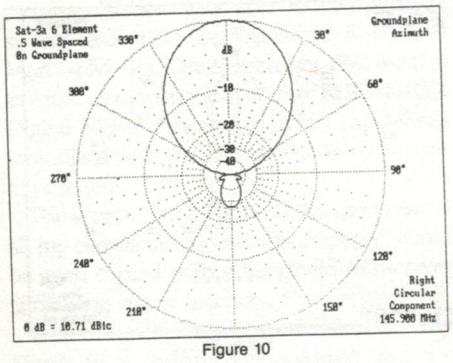


Figure 10

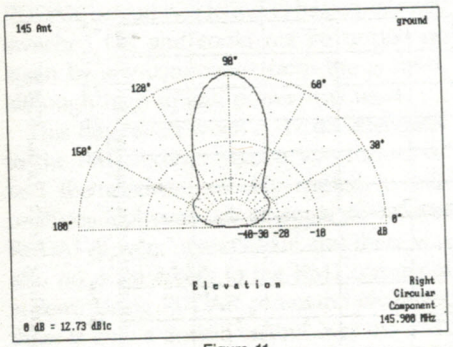


Figure 11

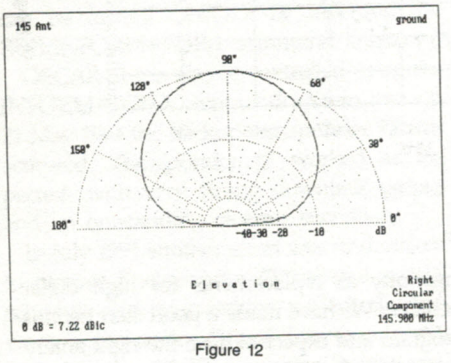


Figure 12

useful for this effort, although the package was designed analyzing for wire antennas, and is definitely not designed to evaluate slot antennas, per se. "Substitute" equivalent wire antennas were used with MNC to achieve our analytic goals. All antennas were evaluated over an infinite ground plane, which is less of an approximation with the higher frequencies. We feel that despite all of these analytic limitations for analyzing our highly specialized satellite antennas, the Beezley MNC software has performed superbly and permitted us to achieve given some very good understandings of our Phase 3D needs.

The CP patch antennas were simulated using a two wavelength square loop with four feed points, each located at the center of the sides. Adjacent sides were feed in a quadrature relationship, producing right hand circular polarization. Each of the patch elements therefore consist of four analytic antenna elements. For a seven element patch array, the analysis uses a total of 28 "elements".

Figs. 19,20 show the reduced gain and increased beamwidth performance achieved with the seven element array employing variable power distribution between the center and outer six elements. This performance change is the result of increasing the power to the center element. Fig. 21 shows the gain and side lobe performance of a seven element array with a center to center spacing of 1.0 wavelength.

Test Data:

The antenna test effort has been principally focused on 0.435 GHz operation, due to the availability of test instrumentation. The test conducted have consisted of feed impedance measurements and (separately) gain comparisons. Literally, this has been a back yard operation, with the two types of tests being done in the respective authors' rear lot territories.

For a start, we constructed a textbook EIA reference antenna. This is a dual dipole unit with the elements located 1/4-wavelength over a 1.0-wavelength ground plane, a large piece of double sided printed circuit board. The antenna is rated to have a gain of 7.7+ or -0.15 dBd. This translates to a gain value of 9.8 dBi, and has been used to date with that value. A 1/3 scale model of the Phase 3D spacecraft has been constructed to permit the testing of the 0.145 GHz antennas using 0.435 GHz RF instrumentation. Tests of the seven element 0.435 GHz array were done on this model, using 1.2 GHz test equipment.

A standard base for 0.435 GHz patch antenna tests was constructed. This base allowed the feed points to be readily adjusted, and permitted different patch elements to be attached for test. The initial tests were conducted with a patch element with a diameter of 370 mm. In fact, while close, the element size was slightly small and the resonant frequency of 0.439 GHz was just off of the top of the satellite band, although located in the center of the range of our test equipment.

Detailed impedance measurements were employed to determine the operating bandwidth of the test antennas, and to insure that the antenna adjustments would result in acceptable feed characteristics. Impedance measurements were made with the test antenna supported away from the operators in a relatively free field with a skyward orientation. Fig. 22 shows the results of a patch antenna using a circular polarization feed.

Antenna gain measurements are somewhat more involved to make. Obtaining a relatively free field is generally considered to be the root of most testing problems. For these back yard tests, a helical source antenna was placed at 20 ft. on a wooden tower. Test antennas were located nearer the ground on a dielectric support (a wooden support made of 2x4 lumber). The range was about 35 ft.,

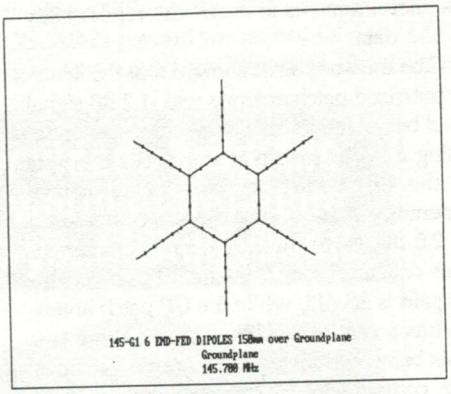


Figure 13

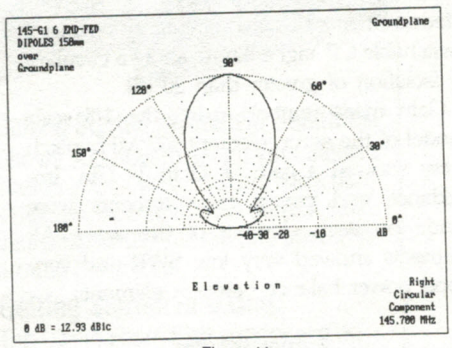


Figure 14

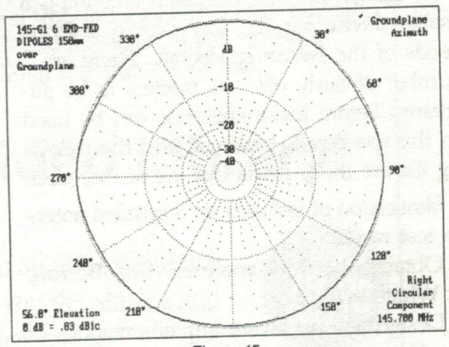


Figure 15

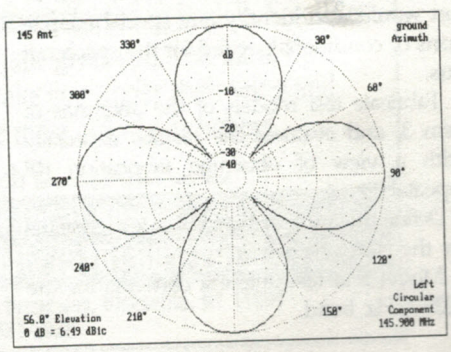


Figure 16

15 wavelengths. Such a close proximity provides a healthy signal with little source power, allowing us to use a relatively simple, but accurate Boonton Microwatt Power Meter, Model 4200. The negative effect of such a close range is the size of the uniform power volume, which inhibits the use of side by side, direct comparison, differential power measurement of the performance of two antennas. Antenna substitution methods were employed for the necessary comparison of the test and reference units. This required multiple measurements to insure the repeatability of the data.

Gain measurements showed that the linearly polarized patch antenna was -1.2 dB signal level below the linear EIA reference antenna, using a linear source antenna. For the tests of the CP patch antenna, a helical source antenna was used, and the patch measured + 2.0 dB above the EIA reference antenna. This data implies that the linear patch antenna gain is 8.7 dBi, while the CP patch antenna has a gain of 8.8 dBic. Despite these two tests being conducted over a period of time, the comparison of the two sets of gain measurements is considered remarkable. Measurements of patch circularity against a switchable CP Yagi antenna show a circularity isolation of greater than 20 dB.

Gain measurements using the 1/3 scale model of the seven element 437 MHz patch array showed a gain of 13 to 14 Dbi. Impedance and power measurements were made on each element of the array. All elements showed very low SWR and very good power balance between elements.

Future Efforts:

We clearly feel that the patch antenna is a usable device for the low profile antenna needs of the Falcon spacecraft. There are a number of fairly obvious matters to be addressed before these antennas can be used on the spacecraft, however, and the following list are those items that we see needed.

1. Verification of test data on a certified antenna test range.
2. Obtain a network analyzer. (Beg, Borrow, or Whatever)
3. Design real hardware implementations of specific antennas for specific bands. This effort would also identify any special adaptations or conditions needed for the spacecraft bus.
4. Fabricate test models of the antennas of item 3, and evaluate the results, especially with a view of obtaining fabrication RF repeatability.
5. Define the implementations of feed systems for the different bands.
6. Model and test antenna concepts for the 0.029 GHz band.

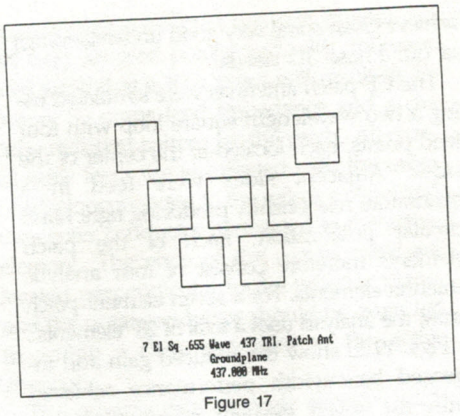


Figure 17

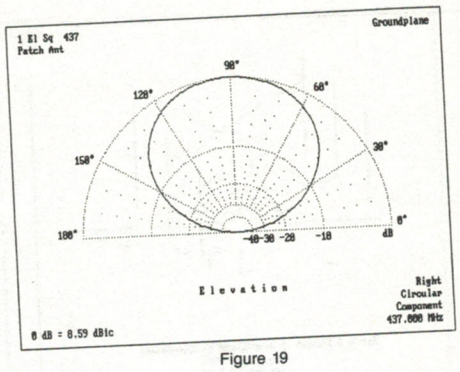


Figure 19

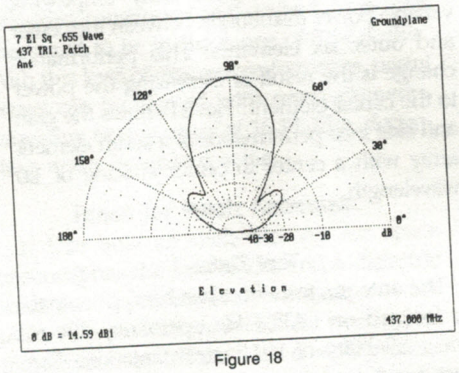


Figure 18

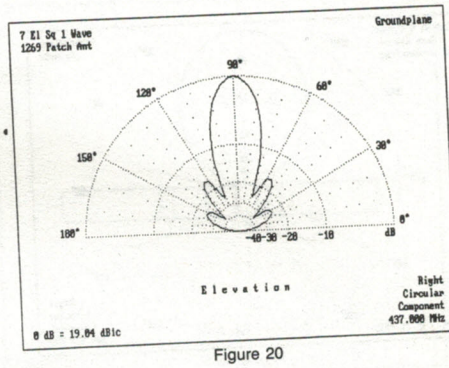


Figure 20

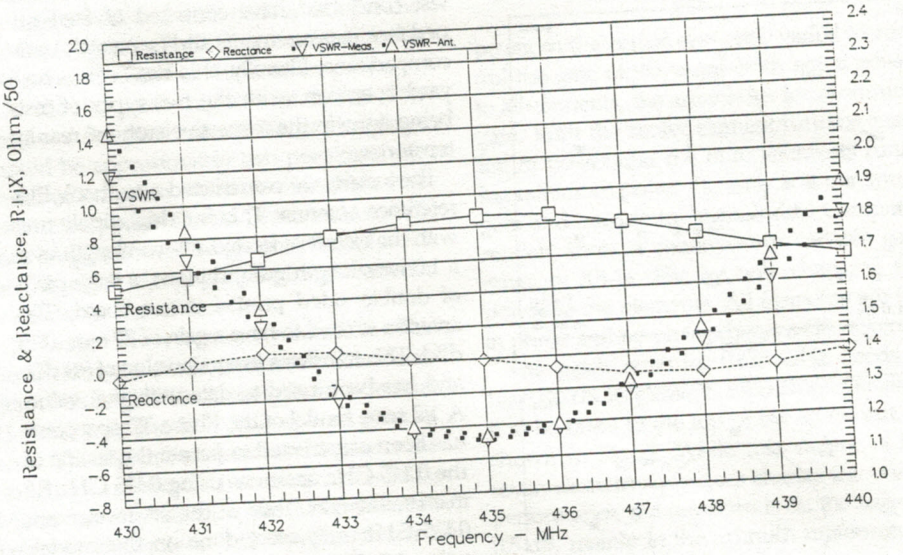


Figure 21

Summary:

These antenna efforts have illustrated to us that reasonable analyses, measurements and tests can be done using unsophisticated equipment. One can substitute patience and ingenuity as replacements for high d facilities. We have made a good start on program and expect to have the right an nas installed on the spacecraft at the pr time.■

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(continued from page 16)

month after the launch of OSCAR-21 on 22 February 1991. The RUDAK-Beacon on 145.983 MHz started transmitting 400 bit/s PSK Telemetry, while the CW Beacon on 145.822 MHz were transmitting Morse telemetry. Both beacons could be copied with very strong signals. After initial tests, the IPS kernal was loaded into the RUDAK R1 system and later the beacon was switched to 1200 bit/s PSK AX.25 format, which is compatible to FUJI, PACSAT etc.

Within a few days the RUDAK ground commandstation was able to complete all system tests, including Digipeater, Robot and Mailbox Modes. On 24 February 1992 the first in-orbit demonstration of the RUDAK-RTX Digital Signal Processing (DSP) capabilities took place with the first Digital Voice/Speech Experiment.

The words "I'm completely operational and all my circuits are functioning perfectly." could be even copied with a handheld transceiver surprising many listeners.

Unfortunately only 1 week later in early March 91 a malfunction occurred and the RUDAK beacon was found to be permanently switched Off and could not be turned on again by any commands from the ground, although high uplink power was used.

This happened when a -12 dB attenuator in the RM1 receiver section was turned off and the receiver probably started to self-oscillate. However, all attempts to recover RUDAK-II were unsuccessful and there was also no more access to the RM1 command system. Using RUDAK command channels, there is only a limited control over the RM1 command system, i.e. the RUDAK Beacon can be turned ON/OFF by inverting the RM1/INFORMATOR-1 command lines.

OSCAR-21 can also be controlled using the INFORMATOR-1 command system and on 21 May 1992 the backup transponder #2 was activated. Transponder #2 worked as expected, with very strong downlink signals and an outstanding receiver sensitivity.

In July 1991 another effort was undertaken to recover Transponder #1 using a special schedule and by switching periodically between Transponder #1 and Transponder #2, including the -12 dB attenuator. But no progress was made at this time and RUDAK still remained off.

In August 1991 efforts were concentrated on building up another command station at AMSAT-DL command station facilities to get improved control over the RM1 command system by using higher uplink power. However, all attempts to send commands to the RM1 system and to switch the transponders did not have any success. It had to be concluded that parts of the RM1 command system had failed, since no commands could be uplinked from the AMSAT-U or AMSAT-DL groundstations.

At the same time the world saw the dramatic changes in the former USSR, which also did not stop at the command center of the INFORMATOR-1 satellite. One must know that all military and civilian USSR satellites were controlled only by the big General Command Center (GCC) near Moscow, which also has some control and tracking stations all over the country. The Ministry of Geology and Science of the former USSR, which owns INFORMATOR-1, was no longer able to pay for the control of the satellite and, for financial reasons, the GCC refused any commanding of the satellite and was on "strike". This indeed affected the OSCAR-21 payload in INFORMATOR-1 and for several months no commands were uplinked to the satellite and most systems were simply turned off.

Fortunately, AMSAT-U and the Adventure Club in Moscow were able to make a contract with the GCC, so that they would again send commands to turn on the A0-21 and RUDAK-II payload. The command access via the INFORMATOR-1 was still functioning and in late 1991, early 1992 the complete OSCAR-21 payload was turned OFF and ON again for a full power down reset. There were

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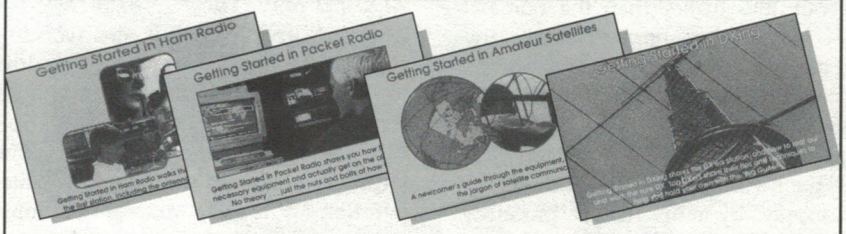

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more and other problems, which hampered the commissioning of RUDAK-II, but in May 1992 a big breakthrough was made.

The Problems and the Solutions

It was discovered that due to self-switching in the RM1 command system the RUDAK Beacon was often switched off or into different modes, like ranging mode. Fortunately the RUDAK command system itself can read the status of those self-switching command lines and has the ability to simply logically invert the commands. A special so-called "Watch&Bite " software routine was written for the RTX-2000 computer and this problem could be completely solved.

Another problem was identified in a DC/DC Converter of a power supply for the RUDAK System. This power supply, which is not part of RUDAK-II, has its own "electronic fuse" to protect against short circuits. Unfortunately the current limit was only set only about 10% higher than the nominal RUDAK power consumption. Like any CMOS parts and computer components, the power consumption is in direct relation to the processor speed and program execution. There might be current spikes above this limit, causing the electronic fuse to switch off the power supply. By reducing the processor speed of the RTX-2000 computer and turning off the R1 computer, the current consumption could be markedly reduced. It was also found, that the current fuse of the DC/DC may be very sensitive to a BUS overvoltage. Therefore a special program from the GCC was installed to better control and regulate (reduce) the BUS voltage in case of overvoltage.

This in fact was completed in late May 1992 and since then RUDAK-II has been in continuous operation. In the weeks before, the RUDAK system was often, after only a few days, suddenly completely switched off and could only be turned on by resetting the "electronic fuse". This was simply done by turning the main power relay off and on.

However there are still some more problems. The receiver sensitivity is sometimes very high, but sometimes much uplink power is necessary. It is unclear if this effect is due to a -12 dB attenuator relay in the RM1 Receiver or due to some interference with onboard transmitters or high power transmitters from the ground. It is planned to periodically switch the attenuator On/Off to verify it's function. The new 70 cm high power "Pave Pawn" radar recently installed in the UK gives additional problems while uploading large amounts of software into the computer and it also hampers commanding. This radar also gives much trouble with commanding AMSAT OSCAR-13 on 70 cm.

Current Activities

After RUDAK-II was successfully recovered from its hibernation in May 1992, all systems were again completely checked out. The RUDAK Hardware Command Decoder with its RM1 Bypass was a great help, since the loss of the RM1 command system.

The RUDAK R1 Computer was found to be 100% operational, but its use will be discontinued because this system is not of much interest due to its old technology. The R1 computer was originally designed for and flown on AMSAT OSCAR-13. It now has only backup functions on OSCAR-21. This includes the RUDAK Mailbox, which was also active for a few weeks. However, the software may be later ported to the RUDAK RTX computer. The 1 MB RAMDISK and the EPROM experiment are also still functioning 100%. The RAMDISK will now be used from the RTX2000 only. The RTX2000 DSP Hardware & Software itself is also working as expected and fully operational. In addition to Digipeater, Mailbox and Robot modes, a new type of Digital Voice & Sound generation was successfully demonstrated for the first time on an OSCAR satellite. In addition to the HAL Voice generation, we have heard the Beep Beep signals from the famous SPUTNIK-1 satellite again coming from space from its original Soundtrack! Another milestone was a realtime FM Repeater using DSP, which means that uplink and downlink are not simply connected together, but everything was done by software. AMSAT OSCAR-21 is the first Amateur Radio Satellite with such DSP capabilities. The FM Mode has been continuously in use for more than two months now and its primary purpose was to directly study the uplink and receiver sensitivity characteristics. However, it was a great surprise to the builders, that the FM Mode was enjoyed and used by so many people. A0-21 is easy to receive, even with a handheld and many stations find this high-flying FM repeater for the first time when their 2 m scanners stop at 145.987 MHz!

Many Hams who are not yet active on satellites and even do not have any SSB equipment are now getting their first experience with satellites. Some of them may later join the linear transponders in SSB as well. In August new software was loaded with 6 minutes of FM Mode, 3 minutes of Digital Voice and 1 minute of 400 Bit/s PSK telemetry. This time RUDAK-II is speaking in the Russian language and in between the FM repeater can be used.

The Future

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continuously for more than 2 months, it has given a new motivation to the RUDAK team and some more work on the software will now be done. The RUDAK-II equipment must be regarded as basically a flying testbed for techniques to be used on Phase-3D. There are still techniques and experiments to be performed however such as: 4800/9600 bps RSM; other modulation (MSK, QPSK); voice and other sounds; voice mail; spoken telemetry and bulletins; other DSP/modem experiments such as SSTV and FAX. There are already plans for a RUDAK-III system on the next AMSAT Phase 3D Satellite to be launched in 1996

Although the discussion is not yet finished, first ideas suggest using the RTX-2000 processor in conjunction with some other processor hardware. The primary tasks for the RTX will be in the DSP Modem techniques, where other CPU's may be responsible for the communications protocols and data handling with various onboard experiments, like the SCOPE Camera Systems.

RUDAK-III should have as many receive channels as possible (only limited by volume and power) and encompass low-speed (1200 bps psk) through to high-speed (64k RSM) capabilities using several protocols (DAMA, FTLO, BROADCAST).

RUDAK-III will handle low and medium speed Store&Forward traffic and a large mass memory (RAMDISK) in the area of 50 MB or more is also intended. High Speed Gateway traffic will be done in near realtime, where RUDAK-III works like a Digipeater or Autorouter to other Gateways.

Developing and constructing the RUDAK-III hardware and software will start very soon now, but the project group is still open to everyone who would like to participate.

Special thanks go to Leonid Labutin UA3CR for his tremendous efforts to coordinate the commanding activities with the General Command Center (GCC). Also special thanks to Gerhard Metz, DG2CV who spent so man nights and who did not give up in getting new software uploaded again to OSCAR-21.■

AMSAT Publications

Satellite Experimenters Handbook:
By: Marty Davidoff, K2UBC
A must for every Satellite enthusiast's bookshelf. Covers; history, fundementals of station construction, tracking as well as advanced topics. $23/25/30

PACSAT Beginner's Guide:
By Mike Crisler, N4IFD
Step by step instructions to becoming PACSAT-active. $12/13/15

Beginners Guide to AO-13:
By Keith Bergland, WB5ZDP
Step by step instructions to becoming active on OSCAR 13. $7/8/10

Beginners Guide to the RS Satellites:
By Gould Smith, WA4SXM
Step by step instructions to becoming active on the RS Satellites. $7/8/10

Decoding Telemetry from the Amateur Satellites:
By Gould Smith, WA4SXM
Describes the telemetry systems of each of the current Amateur Satellites - thru AO-21 and RS12/13. $15/19/25

Weather Satellites Handbook:
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By: Bob Bruninga, WB4APR
Bendix Field Engineering
U.S. Navel Academy 11b
Annapolis, Maryland 21402

Using miniaturized Global Positioning System (GPS) satellite navigation equipment and amateur packet radio, the 110 members of the 13th Company arrived on course and on schedule to deliver the game ball for kick-off ceremonies of the 1992 Army/Navy game. The 13th Company of midshipmen annually runs the football from a final PEP Rally at noon on Friday in Annapolis to the start of the game in Philadelphia at noon on Saturday over a 128 mile distance using pairs of runners every two miles. This year to permit timely and accurate reporting of the progress of the football back to the brigade of midshipmen, the outputs of the GPS receivers were transmitted back to Annapolis using amateur packet radio. The position data was received at the Naval Academy and repeated onto the academy wide local area network. A software program running on PC computers throughout the yard provided graphic displays of the route and the position of the football and chase vehicles.

The initial idea had been to put a handheld GPS receiver, handi-packet and HT inside the football! The football would digipeat via the mobile rig in the nearby chase vehicle and then on to other digipeaters back to Annapolis. As experience with the handheld commercial GPS receiver developed, and as game time approached, the decision was made to place the electronics inside a football helmet instead of the football itself. On the helmet, the GPS antenna would have an unobstructed view of the sky, and the equipment would be less vulnerable to fumbles. Surprisingly, the GPS receiver, the packet radio modem and the HT transmitter plus eight AA batteries fit in place of the usual water/air filled compression pads so that the only external effects of the system were the small GPS quadrifilar helix antenna and the VHF whip antenna. A low profile GPS patch antenna and loaded VHF antenna could have minimized these external effects, but we ran out of construction time. In fact, the helmet was not completed until 1:00 AM on the morning of the run!

Figure 1: Members of the 13th Company preparing for the run and trying on the GPS helment. GPS equipped CHASE vehicle in background.

VHF Relay Network:

To accomplish the data transmission over the extended 128 mile route, members of the Naval Academy Radio Club, W3ADO, joined with the 13th company to provide the necessary communication and data links. The midshipmen installed 2 meter mobiles, TNC's and the GPS receivers in each of the two official chase vehicles and augmented these vans with three HAM equiped private vehicles. Local amateur volunteers set up a 2 meter station in the Oxford Pennsylvania Fire House which is used as a halfway rest station and field command post. A series of three 2 meter voice repeaters along the route provided excellent coverage over the entire 128 mile range. The GPS receivers in the two vans permitted their movements to be tracked while shutteling runners to each of the 64 waypoints. The GPS receivers in the football helmet and the two vans were programmed to transmit a position and velocity packet once every two minutes over the same channel as used for voice communication. Since the three VHF repeaters were independent and not normally linked together, two additional volunteer stations WD4LTO and W3WCQ, midway between the three repeaters provided automatic relay of the data from repeater to repeater back to Annapolis by operating as digipeaters with their receivers on one repeater and their transmitters on the other.

In Annapolis, the data packets were not only distributed to midshipmen throughout the yard, but also retransmitted on HF and via amateur satellite. The Military Affiliate Radio System (MARS) provided an HF frequency for retransmission to military activities and the Amateur Satellite organization, AMSAT, permitted use of the OSCAR-21 satellite for relay to fans across the country.

Play-By-Play:

Although the experiment was considered a complete success, it was not uneventful. During the design, construction assembly and final tuneups, progress was slow but steadily forward. On Thursday we went to pick up the vehicles for installation, but found one with a flat tire and the other one unaccounted for. By the time a vehicle was available, it was 1430 and the motor pool wanted it back by 1530. Fortunately, the first installation was straight forward, and the motor pool supervisor kept the gate unlocked for access to the second vehicle after hours. But a real setback occurred during the installation in the second vehicle. While making a final transmitter level adjustment for the microphone gain, the screwdriver slipped and a blue puff of smoke

filled the air. A quick replacement of the burned out series choke in the power supply did not restore operation and further repairs were abandoned. The third unit that had served as the prototype for the whole project and had been operational for more than a week in the authors car was cannibalized for the chase vehicle, but all the connectors and interfaces had to be modified. This setback cost us four critical hours and reduced the number of GPS vehicles from three to two.

The second vehicle was completed at 2100 and all effort focused on the football helmet which had still never been powered up! The Handi-packet TNC and transmitter came up as planned, but the GPS receiver would not respond. After an hour of troubleshooting, the problem was identified as incompatibility in the RS-232 to TTL converter circuit and the unit was responding at the wrong baud rate. An extra pullup resistor solved the interface problem and the baudrate of the TNC was modified to match the incorrect rate coming from the GPS receiver. The unit was finally operational by midnight and taken outside to see full sky. The GPS quickly synchronized and within minutes was downloading ephemeris. An hour later it was retrieved and final assembly within the helmet began.

After precious little sleep, the midshipmen began distributing the display software and setting up displays in public places throughout the Yard, the main duty office, the midshipmen radio station, the snack bar, the 13th Company command post and the wardroom. Andrew Parker WV1B assembled his portable packet laptop outside at the site of the PEP rally so the Admiral could see how it worked. With 30 minutes to go, both chase vehicles, the football and all displays were operational. The helmet was initialized and everyone headed for the send-off PEP rally. Amidst speeches and cheers, the football was passed by Admiral Lynch, the Superintendent of the Academy to the lead runner and his companion donned the GPS helmet as the run began. At the west gate, the runners joined with the lead chase vehicle and the long distance portion of the event began. The laptop display showed the position of the two vehicles, but the football helmet was still reporting itself at the starting point! We gathered together our bag of tricks and headed off to overtake the errant helmet. We caught up to the ensemble at the first two mile exchange point and the runner saddled with the helmet was only too happy to relinquish it for analysis. Although we were now down to two out of the original four GPS systems, we realized that the the lead chase vehicle was always within eyesight of the runners and that if we changed its callsign to FBALL instead of CHASE-l, the objective of reporting the position of the football would still be met. We brought the football helmet back to the lab for troubleshooting, but never quite got to it. The emergent logistics and communications needs of the runners soon overtook us.

Coordinating the positioning of over a hundred individuals stretched along a 128 mile route over and 18 hour period provided enough distraction for the remainder of the evening. After sunset in the worst section of Baltimore, the chase vehicle lost track of the runners in rush hour traffic and the shuttle vehicle had a flat tire (and no spare). Desperate searching by the van and several midshipmen cars was unsuccessful for almost a half hour until the football and two runners stepped out of a taxi at a subsequent checkpoint. They had become hopelessly lost and hailed a taxi to help them find the proper intersection. Then the spare tire of the chase vehicle was used to repair the shuttle van and another 50 mile round trip back to the motor pool was inserted to get two spares.

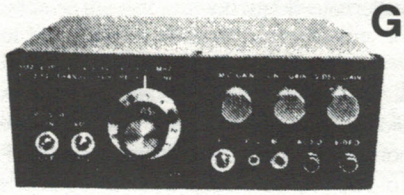
Monitoring the local area network from the satellite control room, we could see the software proliferating as copies of the software proliferated. By 2100 as many as 15 displays throughout the Academy were on line. About this time the position collection and dissemination software crashed due to not enough memory. The software was designed to track and display the movement of the Academy Boats during summer cruises where HF packet position reports every 10 minutes were expected. The every two minute reports for the football run, exceeded the size of the variable arrays before the normal 0300 housekeeping routine had a chance to purge the extra data. This was soon fixed, but all the displays were not updated for over a half hour. By this time the excitement of tracking the football was catching on in the local amateur radio community and dozens of stations along the route came online to observe the movements of the entourage. Six of those stations had obtained copies of the tracking software and the chatter on the voice net was exciting as everyone shared the same graphic display picture.

UHF SATCOM Relay:

AO-21 has performed a number of specific digital communication tasks in its two years in orbit. Recently this all digital processor was programmed to simulate a mode B analog transponder by analog to digital converting the uplink and then digital to analog converting the data on the downlink. Although this technique was overly complex for the function performed, it has proved extremely popular with amateurs worldwide. With hundreds of stations on the uplink, the power necessary to capture the detector has slowly grown upwards due to contention on the uplink. Still, conversations are gentlemanly and brief, with typically a dozen or so stations able to exchange comments during a 10 minute pass. Over a 10 minute cycle, the transponder is on for 6 minutes, a synthesized Russian voice makes announcements for three minutes, and one minute is dedicated to telemetry.

Our experiment was to attempt to relay our one second position reports once every two minutes via this quasi analog transponder during the Friday evening and Saturday morning passes of AO-21. There were three passes during each attempt with the center pass being reasonably overhead. Unfortunate-

AMATEUR TELEVISION



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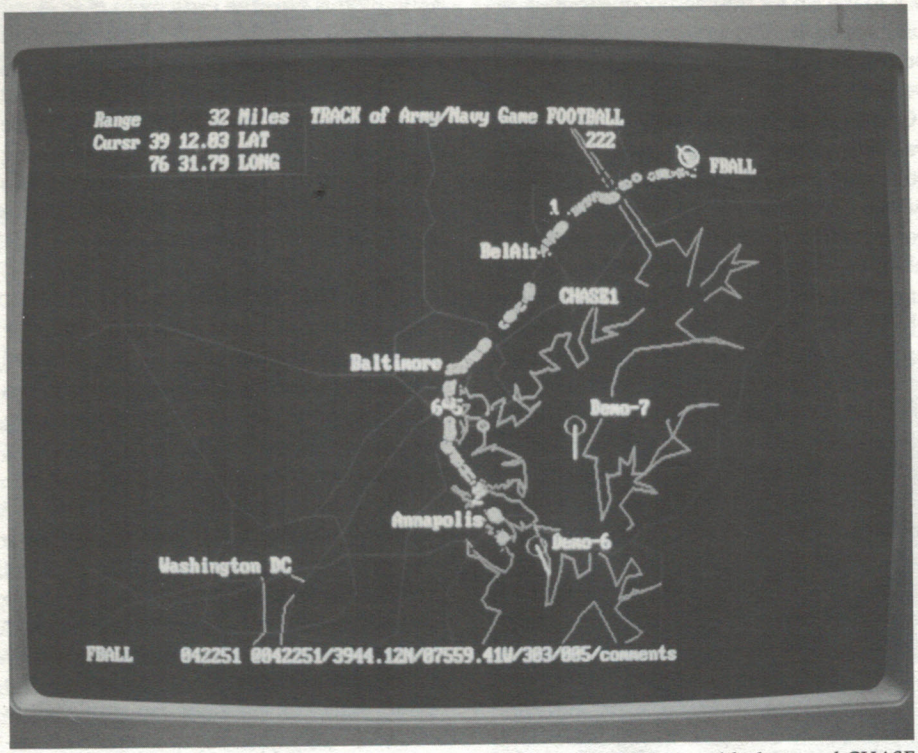

Figure 2: View of the tracking program showing the Football north of Baltimore with the second CHASE vehicle several miles behind. Although a 32 mile scale is shown, the software can display any range from 1029 miles down to ½ mile. The bottom line shows the raw position report. Two Demo boats are also shown underway in the Chesapeake Bay.

ly, with the flat tires on the chase vehicle and lost runners, a last minute attack of 'connectoritas' caused us to miss the Friday night overhead pass by 5 minutes so that only 5 watts instead of the intended 100 watts got to the antenna. Still, we did audibly hear our signals on the downlink, but they were too noisy and uncopyiable. A station in New Jersey also reported hearing the data. By the next pass we had located the necessary adaptor cables and connectors, but it was over the central US with at least a 2000 mile slant range, and even with 100 watts at the antenna we were several dB below capture. Since everyone headed to the game Saturday morning, the station was left in automatic with the antennas pointed towards the closest point of approach of the next overhead pass. On return to Annapolis after the game, we found the entire Satellite station without AC power due to a routine transformer inspection which had secured power at 0500!

High Frequency Relay (HF) :

Finally, our experience with broadcasting the position reports over HF was disappointing. There was a solid teletype signal on our assigned frequency for the full 24 hours that we were in operation! We had chosen to use a MARS frequency instead of an amateur radio packet frequency because we thought we would have less congestion on an assigned MARS frequency. The interfering signal was not another MARS station but appeared to be an encrypted military or government broadcast. Since the frequency had been widely announced for the experiment, a last minute frequency change could not have been disseminated in time. Unlike on amateur frequencies, a 1 kHz slide up the band away from the interference was not permitted. Also any other signal on a HAM frequency is half duplex and changes from time to time and rarely continues for more than an hour or so, as digital conversations come and go. Trying to compete with a RTTY broadcast, however, is another matter!. Next year, we will operate in the amateur bands and publish primary and alternate frequencies.

Summary:

Despite the difficulties, the experiment was considered an outstanding success. We demonstrated to the midshipmen a combination of HF, VHF and satellite communications and introduced them to the technology of miniaturized GPS receivers. Members of the radio club gained hands on communication experience in a tactical environment and had a lot of fun. The 110 members of the 13th company learned the advantages of radio communication in managing logistics over an extended range and hundreds of midshipmen were able to share in the excitement of the 13th company as they observed the progress of the football on display screens throughout the yard. The distribution of the position reports via the recently installed high speed Naval Academy local area network demonstrated the capabilities of distributed processing power similar to the future networks anticipated on Naval ships. Until next years run, the GPS position reporting capability will see application on the Naval Academy boats during summer cruises, keeping track of over 400 midshipmen on as many as 20 units at sea.■

A Tribute to Gus

Clarence L. Humber, VE1HD
R. R. 2 Marion Bridge
Nova Scotia, Canada, B0A 1P0

On Friday, February 26, 1993 Amateur radio lost a good friend; Gus, KI5NT. His passing is mourned by many friends and acquaintances.

In the most recent years of the hobby if Gus was not, "Down at the creek" he was on the satellites. This is where I met him and out of that grew one of the nicest friendships I have ever had. He surely had a lot of friends besides myself and he always had time to help a newcomer or someone more experienced if they needed anything.

His wide and varied experiences in life gave Gus knowledge that most of us do not have. He was only too glad to share that knowledge with any and all. Along with the technical information he shared, he still found time to tell us stories about some of his travels or places he worked. We'll all miss that sadly.

It became a bit of a tradition when someone new called in, to ask that person what he thought Gus's call was. He would give it without phonetics and invariably the K ah 5NT was usually copied as "KR5NT" to the amusement of all, including Gus. About that time, he would accuse Rex G4JUJ of saying that he, Gus, had an accent! That beautiful way Gus rolled some of his words will surely be missed by all of us for a long, long time.

More than anything else, Gus loved the Satellites. He was one of the best ambassadors the Amateur Space program has had. 145940 mhz on AO-13 was one of his favourite places to "blither", and over the years he made a lot of friends there. One thing for sure, for those of us who use that frequency, it will not be the same, without K ah 5NT.

To his family and friends- You have known and will miss a wonderful person and my heartfelt sympathy goes out to you. I never met Gus in person but he made me feel I had known him a lifetime. Those happy hours were, "Almost perfect" - Just like him.■

Heard on the Downlink

By: John Hansen, WA0PTV

Welcome to my second compendium of information, tips and short subjects for *The AMSAT Journal*. At this writing the first issue containing this feature has not yet hit the streets, but ye ole editor assures me the preliminary response has been relatively positive so he's decided not to cancel me and to double my salary. Hopefully, the next issue will contain YOUR favorite tricks, tips and observations. Send them to me at any of the addresses at the bottom of this column.

This is an AO-21 Alert!

I suppose most of us are always looking for new ways to make our fellow amateurs more aware of satellite communication. Here's one way that I've found to be particularly effective in my local area. I keep track of roughly when AO-21 passes are going to occur when those passes are not in the middle of the night. Then when I'm in my car I keep the downlink frequency (145.985/145.99) in the scan pattern of my mobile radio. Oscar 21 is so loud that you can easily pick it up on a mobil radio or even a handheld. When I hear the satellite I then switch over to the local repeater and announce "This is an Oscar 21 Satellite Alert! Tune to 145.99 to copy the satellite downlink!" This has received a very favorable response among the local ham community.

Now Andy MacAllister (WB5ZIB) reported in an issue of 73 Magazine last year that he was able to work AO-21 with an HT. To be fair, he didn't say it was easy and he did say the signals were very very weak. On the other hand, to date I've been unsuccessful working the satellite from my car with 35 watts. I'd love to hear from anyone who has figured out how to do this.

However, it has occurred to me that if I took my mobil radio (an Alinco 590) out of my car and set it up at home with my regular satellite antennas, some interesting possibilities would emerge. Almost anyone in the local area with a 2 meter radio will be able to hear AO-21, particularly on high passes. All that prevents them from actually using the satellite is a means of getting their signal to the satellite. This is particularly a problem if they don't own a 70 cm radio or own one that won't transmit on 415.015 Mhz. With my mobile unit at home, however, I could set up the 2 meter receiver on 146.59 Mhz, and put the crossband repeat function on to put the signal out on 435.015. Then end users in the area could put their radios on 145.99 Mhz with a +600 Khz offset and work other stations through the satellite. Or if you can get them to program an oddball split, you could have them transmit via the local repeater and use the crossband repeat on your mobil radio to relay the repeater output to AO-21. I have not tried this yet, but there really isn't any reason it shouldn't work. Let me know if you have any success with it.

One word of caution. While it would technically be legal to set up this kind of system and leave it running unattended, it seems to me that it would be unwise to do so given the likely resulting levels of congestion on the satellite. When AO21 becomes congested absolutely no signals can be heard by anyone. The satellite just sounds like its experiencing very bad feedback. Some ought to be around to pull the switch on the link when this happens, or the satellite pass will be lost to everyone.

The KLM 40CX Antenna

Surely this is one of the two or three most popular 70 cm antennas for use on the satellites today. And for a good reason; it is an outstanding performer. While there are now a couple of other antennas in its class, when it was introduced some years ago there was nothing that really came close. Please don't interpret this as an ad for the 40CX; there are several other very fine 70cm satellite antennas out there. But because of its early arrival on the scene a lot of satellite operators own the 40CX and there are some known problems with it that you can easily head off early.

Perhaps the biggest problem with this antenna is a tendency to get water in the tubular driven elements. Apparently the seals in the ends of the elements are not entirely water-tight. There are a couple of ways to handle this. If you buy one new, or know that your's is currently dry inside, you can use some standard sealer (like RTV compound) to seal the elements completely. For many of us, however, we discovered this problem because the swr jumped and the performance of the antenna declined dramatically. If this is the case and you are sure there is no water in the feedline (see the last issue), then there is a good chance you have water in the driven element. A number of us have solved this problem by drilling a tiny drain hole through each of the driven elements tubes, at the bottom, so the water can drain out. You have to drill the hole through the entire element (not just one wall) so that air can come in as the water runs out. I did this about 3 years ago and was surprised at the quantity of water that came rolling out. However, since the drilling the problem has not re-occurred.

The KLM 40CX is perfectly balanced about its mounting point, IF that is, you never hook a feed line up to it. Most satellite operators prefer to hook a feedline up their antennas rather to simply leave them on the roof or tower as an object d'art (ever notice how pretty a really large cross yagi is?). Unfortunately, the moment you hook a feed line up to this antenna it redistributes the weight and pulls the back end down. There are 3 possible solutions to this problem. The first is: do nothing. That's what I've been doing and I'm not happy with the outcome. It seems like every six months or so the antenna begins to creep out of position and before I know it when the elevation rotator reads 0 degrees, the antenna is pointed about 20 degrees in the air.

A second solution is to route the feed line back up the antenna boom and then across the cross boom to the rotator. Thus you don't have the feedline pulling down the back of the antenna. I know some very reputable satellite ops that have used this approach even though it violates the conventional wisdom of not running the feedline through the pattern of the antenna. I have not adopted this approach because I didn't pay for all that gain just to give some of it back.

The third approach is to redrill the mounting holes where the U bolt attaches the antenna to the crossboom somewhere where the antenna is well balanced with the feedline on. This is more work, but I've heard it works well. Unless someone comes up with a better plan, I plan to do this in the Spring.

Satellite operators have reported a couple problems with the polarity switchbox on the 40CX. The box does not appear to be as well sealed as it should be and I've found bird's nest material lodged in there in mine. Others have reported water. The obvious solution is to take some duct seal (see last issue) and thoroughly seal the bottom of the box. The duct seal has the added benefit that it is easy to remove (especially compared with coax-seal) if necessary. Others have reported problems with damaged caused by the stress of the coax wiggling back and forth as the antenna goes up and down. This apparently can cause the connection INSIDE the box at the 'N' connector to fail. One solution here is to route the coax from the connector on the bottom of the box back up over the boom and tape it there very well. Don't pull it tight, leave a small loop. This keeps the coax from wiggling back and forth. At least at my station it does not seem to have degraded the antenna performance significantly.

I'm not trying to pick on the 40CX here, it is an outstanding antenna. However, by taking some precautions early on, you can save a lot of trouble later. By the way, if you buy this antenna new, set aside at least 6-8 hours for construction proceed very carefully; the measurements are critical.

Getting to Your Antennas

Everyone knows that one of the advantages of satellite communication is that you don't have to put your antennas high in the air to be successful. However, many satellite operators are forced to mount their antennas

(continued on page 31)

Apogee View
(continued from page 3)

But, competent individuals and/or groups to design and build transmitters for 2 meters, 2.4 GHz and 5.6 GHz are yet to be identified. A similar statement can be made for the various receivers, although those entail much less stringent techniques. The thing that makes the transmitter job a tough problem, is the need for relatively high power, high efficiency, linear amplification of a band of frequencies.

We continue to look for people or groups willing to join the phase 3D design team and assume the responsibility for challenging task of supplying one or more of these somewhat exotic transmitters.

If interested, please get in touch with me.■

Phone: 210-896-0336
E-Mail w3xo@amsat.org
or CompuServe 70323,2750

AMSAT News

Board of Directors Nominations:

Nominations are sought for the AMSAT Board of Directors. Directors are elected by the membership for a two-year term. Any member society or group of five current members can nominate a member to run for the position.

This year there are four seats to be filled. Those directors whose seats are up for election are: Bill Tynan, W3XO, Jan King, W3GEY, Junior DeCastro, PY2BJO, and Dick Daniels, W4PUJ. All nominations should be sent to: AMSAT BOD Nominations, 850 Sligo Ave., Suite 600, Silver Spring, MD 20910. They should arrive no later than June 15th, 1993.

AMSAT at Dayton

AMSAT will again be exhibiting at the Dayton Hamvention. Besides providing the latest in software and publications at the booth, AMSAT members will be making a number of presentations during the weekend. If you are planning a trip to the Hamvention, make sure to stop by the booth and leave time to attend the presentations.■

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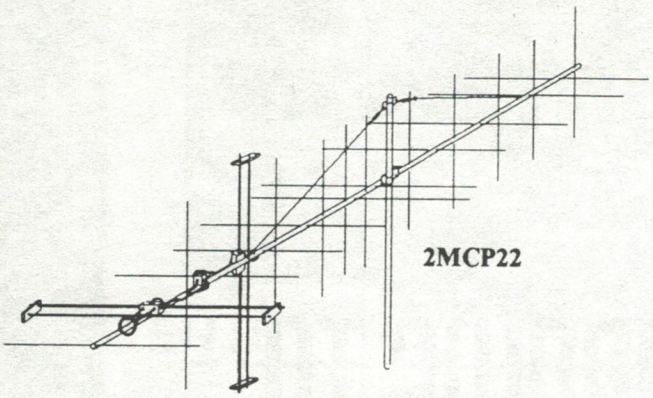
Satellite Orbital Elements

By Dick Campbell, N3FKV

Satellite	AO-10	UO-11	RS-10/11	AO-13	FO-20	AO-21	RS-12/13
Catalog Number	14129	14781	18129	19216	20480	21087	21089
Epoch Time	93086.54729714	93084.58379548	93091.89179851	93090.76117218	93080.61382554	93091.54208460	93088.74695223
Element Set	980	407	586	586	441	730	397
Inclination	27.0769	97.8193	82.9224	57.7111	99.0557	82.9389	82.9219
RA of node	33.3255	114.6541	295.0105	324.6407	313.3439	109.5563	341.0305
Eccentricity	0.6013784	0.0010496	0.0011527	0.7251766	0.0539952	0.0033840	0.0028665
Arg of Perigee	68.5627	266.6006	162.5656	311.7763	285.0751	234.5714	267.5693
Mean Anomaly	343.3267	93.3996	197.5893	5.9706	69.1261	125.2271	92.2177
Mean Motion	2.05875703	14.68922379	13.72312279	2.09726329	12.83218206	13.74513505	13.74018187
Decay Rate	3.0e-07	8.25e-06	4.1e-07	-2.01e-06	-1.3e-07	5.6e-07	6.5e-07
Epoch Rev	7358	48444	28938	3673	14608	10891	10761
Checksum	317	351	334	306	294	289	329
Satellite	AO-16	DO-17	WO-18	LO-19	UO-22	KO-23	MIR
Catalog Number	20439	20440	20441	20442	21575	22079	16609
Epoch Time	93089.76783177	93088.15533154	93084.76501357	93086.24143936	93091.08602551	93070.30867943	93091.81813295
Element Set	549	551	553	550	249	94	982
Inclination	98.6231	98.6270	98.6263	98.6276	98.4805	66.0779	051.6189
RA of node	175.7210	174.3215	170.9940	172.6190	168.4281	169.1155	242.8855
Eccentricity	0.0012061	0.0011989	0.0013018	0.0012795	0.0007380	0.0009657	0.0001794
Arg of Perigee	53.8452	59.1983	68.4482	63.8544	165.3488	210.7767	133.1812
Mean Anomaly	306.3845	301.0379	291.8085	296.3951	194.7914	149.2671	226.9386
Mean Motion	14.29814790	14.29948204	14.29928420	14.30017242	14.36803758	12.86276851	15.57656781
Decay Rate	2.11e-06	2.17e-06	1.93e-06	1.87e-06	2.59e-06	.00000000	7.355e-05
Epoch Rev	16623	16601	16553	16575	8958	2725	40722
Checksum	313	302	317	317	342	310	334

QUESTIONS AND ANSWERS (COMMONLY ASKED)



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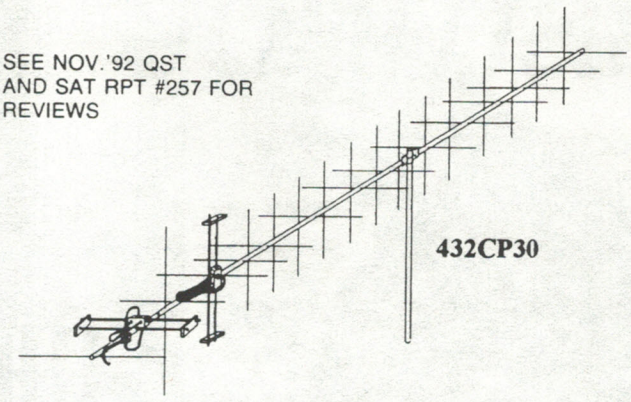
REVIEWS



QUESTIONS

1. Do the feedlines have to come off near the rear of CP antennas?
2. Can I mount a metalic feedline support boom out from the main boom?
3. What is the best element orientation for CP Yagis?
4. Can I mount two 436CP30s inside my two 2MCP22s?
5. Does the 2MCP22 absolutely need a vertical boom support?
6. Why doesn't M2 provide a RHC LHC switching unit?
7. Should I use a preamp with my OSCAR system?
8. Should I mount the preamp at the antenna?
9. I Can I mount my OSCAR system up at 70 ft. above my HF Yagis?
10. What is the minimum clearance to the roof when I elevate the array?
11. What kind of feedline do you recommend?
12. Can I use my OSCAR system for terrestrial SSB/CW or FM?
13. Why should I buy the 2MCP22 when the 2MCP14 will hear the OSCAR?

If you still have questions, We will be glad to chat with you further. That is how we add even more value to the finest antennas on the market!

ANSWERS

1. To avoid cutting the circular field that surrounds a CP antenna and disturbing the pattern and VSWR, the feed line should come off the rear.
2. Yes, Metal tubing supporting coax will have little effect on performance.
3. Any mounting works but for easiest feeline routing, the X shape works best.
4. No because the 2m antennas act like a shield and 70cm antennas suffer.
5. No, only in heavy Ice conditions, otherwise it is optional.
6. We have gone for reliability by eliminating a major loss and failure area.
7. A preamp will usually improve your signal to noise ratio on 2m and 70cm.
8. For feedlines over 50 feet, antenna mounted preamps are recommended.
9. Yes but for mechanical and maintenence reasons it is not recommended.
10. The reflectors should clear the roof by 4 to 6 inches.
11. Don't Skimp here. Hardline is best but 9913 is the best bang for the buck.
12. Absolutely! and CP is sometimes very helpful on terrestrial paths.
13. You will be able to hear the 'weak ones' with the larger 2MCP22.

More detailed answers are available by phone or FAX. We could probably write a book on CP antennas!

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Heard on the Downlink

(continued from page 29)

up in the air to avoid trees or merely to get them out of the way. If you are planning to put up your own satellite station with directional antennas consider this: Do everything you can to put your antennas somewhere where you can get to them. This is not like installing an HF beam where you can put it up and forget it for a few years. Chances are you will need to do something to those antennas about every six months. You'll need to adjust the way they are pointed, you will decide to upgrade your preamp, you'll have water somewhere. It is impossible to anticipate all the reasons you will decide you absolutely have to get to those beams, but for almost every operator I know the urge to go do some "work" on the antennas strikes about once every six months. And just getting up a tower is rarely good enough. Because there is a crossboom involved, getting to the antennas themselves is somewhat more difficult than simply climbing a tower.

So if you hire a bucket truck to put your beams up, bear in mind you may be hiring the bucket truck guy about once every few months to come back and do something for you. Better to put the antennas where you can get to them if at all possible.

Software of the Month

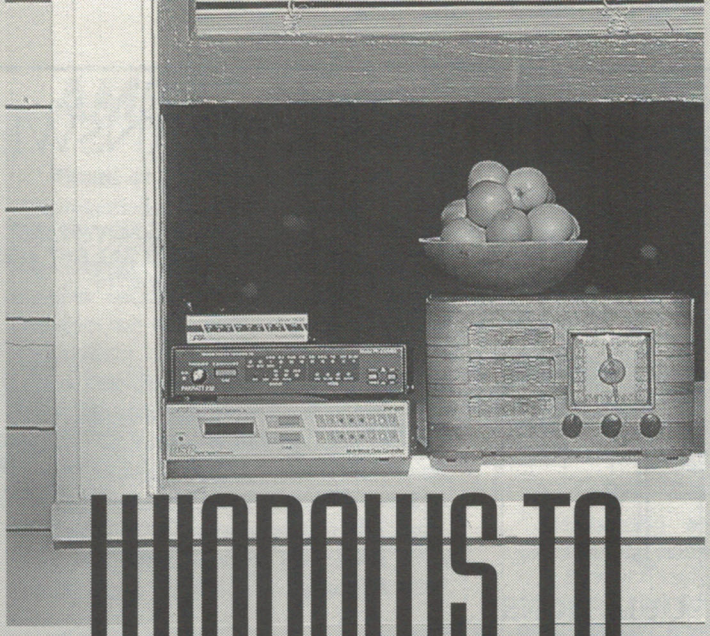
I promise this will absolutely, positively be the last month I mention my own software as the software of the month. Next issue its someone else's turn. I have, however, completed work on ver 1.5 of the gateway node software for pacsats. This software integrates a standard packet bbs with a packet satellite groundstation so that the bbs users can access the satellite in pretty much the same way they could if they owned their own satellite stations. This is not the gateway mail forwarding system that has been described in previous issues of this journal, but rather an entirely different system that allows individuals without satellite stations to essentially get on the birds. A more detailed description is contained in the March issue of 73 Magazine. The software is available directly from me by sending a disk and disk mailer with return postage.

LOS

How valuable is ham radio? How valuable is AMSAT? Everyone must answer that question for themselves. For me, its kept me sane over the past month. Five weeks ago I had a heart attack at the tender age of 39. During the first week out of the hospital every idle moment was spent wondering if every random pain in my chest wasn't an indication that I was heading, as Fred Sanford used to say, for "the big one". I wasn't allowed to do much the first week but I could sit behind the radios, and in particular work the satellites. As well wishes poured in from literally around the globe via UO22 and KO23, I'd never been so glad to be a ham and to be involved with AMSAT. I hope it never happens to you, but if it should, be glad you have something intellectually and socially interesting to see you through the recovery.

Please send in your ideas and tips for the next column. Remember a lot of folks who are only getting started in satellites read this Journal. Remember how challenging you thought it all was when you got started. What now seems obvious to you may be just the right piece of information at just the right time for someone else. The author can be contacted via any of the following mechanisms:

On KO-23, or other satellites when you find me on.
On Packet: WA0PTV @ WA0PTV.
#WNY.NY.USA.NA
On Compuserve: 70353,460
On Internet: hansen@jane.cs.fredonia.edu
US Mail: 49 Maple Avenue, Fredonia, NY 14063■



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